Reconnaissance Report
Local Study Cost Sharing Agreement
Shore Protection And Erosion Control Project

Nantasket Beach Shore Protection Study Hull, Massachusetts

US Army Corps
of Engineers
New England Division

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The purpose of this reconnaissance study is to determine whether further planning to alleviate the storm damages in the study area is in the Federal interest. During the "Halloween Storm" of October 30-31, 1991, the concrete sea walls along the Metropolitan District Commission Nantasket Beach Reservation in Hull, Massachusetts, experienced a substantial amount of damage and undermining. In addition, a large volume of beach material seaward of the walls was also lost. Most past damages, have occurred to the existing concrete sea walls including the ramps, stairs, walkouts, riprap and sidewalks as well as backshore flooding due to wave action and overtopping. Total costs for plan is $4,220,000 and total annual charges is $383,000. The average annual benefits from damages prevented, estimated at $2,737,200. The benefit to cost ratio is 7 to 1.

The reconnaissance report demonstrates that a sandfill protection plan at Nantasket Beach is environmentally, economically, and technically feasible and concludes that further planning to alleviate shore damages and flooding are in the Federal interest.

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SECTION 103
SHORE PROTECTION AND EROSION CONTROL
RECONNAISSANCE REPORT

NANTASKET BEACH

HULL, MASSACHUSETTS

1993
U.S. ARMY
CORPS OF ENGINEERS
NEW ENGLAND DIVISION

EXECUTIVE SUMMARY

This report was prepared by the New England Division, Corps of Engineers at the request of the Metropolitan District Commission (MDC). During the "Halloween Storm" of October 30-31, 1991, the concrete seawalls along the MDC Nantasket Beach Reservation in Hull, Massachusetts, experienced a substantial amount of damage and undermining. In addition, a large volume of beach material seaward of the walls was also lost. The critical nature of the situation prompted the MDC to write a letter to the Corps on January 6, 1992 requesting assistance in protecting the seawalls and backshore from future storm damage and flooding.

Significant storm damage to the concrete seawalls, riprap, stairs, ramps, walkouts and sidewalks along with backshore flooding from waves overtopping the walls, as described in the Hydrologic and Hydraulics Appendix D, has occurred in the past and will continue in the future if no protective measures are taken. The most severe damage in recent times occurred during the northeast storms of October 30-31, 1991 and December 11-12, 1992 when a 400 foot section of the concrete seawall tipped over. It is estimated that these two events together caused almost $2,500,000 in damages to the MDC facilities and another $150,000 or more to the backshore.

Nantasket Beach is part of a narrow sand spit formed from eroded glacial sediments which extends in a NW-SE direction from the bedrock mainland in the town of Hull. The study area is approximately 6,800 feet in length and lies at the southerly end of the spit just north of Atlantic Hill. The beach faces the open Atlantic Ocean to the northeast and is backed by concrete seawalls and riprap, which immediately protect backshore parking areas, a pavilion and a bath house. Further back and parallel to the seawall and beach are Nantasket Avenue and Hull Shore Drive, which front approximately 55 commercial, 26 residential buildings and a sanitary facility in the 100-year flood plain. At the north end of the study area, the seawall and riprap protect Nantasket Avenue, where the road provides the sole access between the mainland and the northern two-thirds of the Town of Hull's land area and its population. With its immediate exposure to the Atlantic Ocean and its proximity to the urban areas of greater Boston, the study area exhibits a very heavy summer population and an increasing year round population. Use of the beach and adjacent backshore facilities is very intensive in the summer. (See Location Map - Figure 1 in this report).

This report describes the problem and its effects on the MDC Nantasket Beach Reservation and the town of Hull and discusses several alternative solutions designed to reduce shore damage and backshore flooding. The protection plan proposed in this Reconnaissance Report for further study provides for the construction of a beach fill project with a 75 foot wide level beach berm at elevation 17 feet above mean low water (mlw) extending seaward from the concrete seawall with a fronting slope of 1 vertical to 15 horizontal that extends downward until it intersects the existing ground. It is anticipated

that the beach fill will be obtained from a land-based borrow site within a 35 mile radius of the beach and that will have a median grain size of about twice the native material to increase its stability against erosive forces.

Preliminary field investigations, as well as initial coordination with Federal, State and local resource agencies, have not revealed any outstanding or unreasonable environmental issues or concerns. A draft cost sharing agreement between the U.S. Army Corps of Engineers and the local sponsor, the Metropolitan District Commission, for the feasibility phase of the study is included. The tasks to be performed during the course of the study are described and the cost for each area detailed.

The total scheduled construction costs of the plan put forward in this report is $4,220,000 and the total annual charges, consisting of interest and amortization of the first costs and the cost of periodic sand nourishment, based on historic records, is $383,000. Average annual benefits from damages prevented are estimated at $2,737,200. The benefit-cost ratio is 7.1.

The overall financed cost of the project is summarized as follows:

	Federal	Non-Federal	Total
Scheduled Construction Cost	$1,775,000	$2,445,000	$4,220,000
Study Cost (Reconnaissance & Feasibility)	225,000	100,000	$325,000
Unscheduled Construction Cost (Nourishment)	-0-	1,370,000	1,370,000
TOTALS	$2,000,000	$3,915,000	$5,915,000

The reconnaissance study described in this report demonstrates that the project is environmentally, economically and technically feasible and concludes that further planning studies to alleviate shore damage and flooding are in the Federal interest.

The non-Federal sponsor, the Metropolitan District Commission, strongly supports the project, as noted in their June 8, 1993 letter contained in Appendix B.

NANTASKET BEACH
HULL, MASSACHUSETTS
SECTION 103
RECONNAISSANCE REPORT

TABLE OF CONTENTS

TABLE OF CONTENTS

(continued)

NANTASKET BEACH
HULL, MASSACHUSETTS
SECTION 103
RECONNAISSANCE REPORT

INTRODUCTION

The Nantasket Beach study area consists of the Metropolitan District Commission's (MDC) Nantasket Beach Reservation and the adjoining backshore area that lies in the town of Hull, Plymouth County, Massachusetts. The study area includes the first 6,800 feet of a 17,000 foot elongated spit extending along a NW-SE axis into Massachusetts Bay from Atlantic Hill on the south to Point Allerton on the north. (See Location Map - Figure 1). The study has focused on measures to reduce future damaging effects of wave and tidal action on the existing concrete seawalls and backshore flooding during periods of wave overtopping.

Nantasket Beach's location on the Atlantic Ocean and close proximity to the urban areas of greater Boston, cause it to have a substantial increase in population during the summer months. Use of the beach area and adjacent land is very intensive in the summer.

Wind driven waves from the east have caused extensive loss of beach material in front of the concrete seawalls. In turn, this has left the walls vulnerable to damage and undermining caused by wave and tidal action and has increased the amount of interior flooding during periods of wave overtopping, as defined in the Hydrologic and Hydraulics Appendix D.

This Reconnaissance Report presents the results of the investigations that were conducted to determine the feasibility of providing local shore and flood protection to the area that were undertaken at the request of the MDC in their letter of January 6, 1992.

AUTHORITY

This report was prepared under the special continuing authority of Section 103 of the 1962 Rivers and Harbors Act, as amended, for the purposes of shore protection and flood damage reduction from coastal storms.

STUDY PURPOSE AND SCOPE

The purpose of this reconnaissance study is to determine whether further planning to alleviate the storm damages in the study area is in the Federal interest.

Most past damages, especially in the recent past, have occurred to the existing concrete seawalls including the ramps, stairs, walkouts, riprap and sidewalks as well as backshore flooding due to

wave action and overtopping. This study reexamines previous study findings in this area, especially the previously authorized sand fill project, and on a reconnaissance level of detail, examines the entire width of the spit in the study area with respect to shore damage and flood reduction. (See Appendix D).

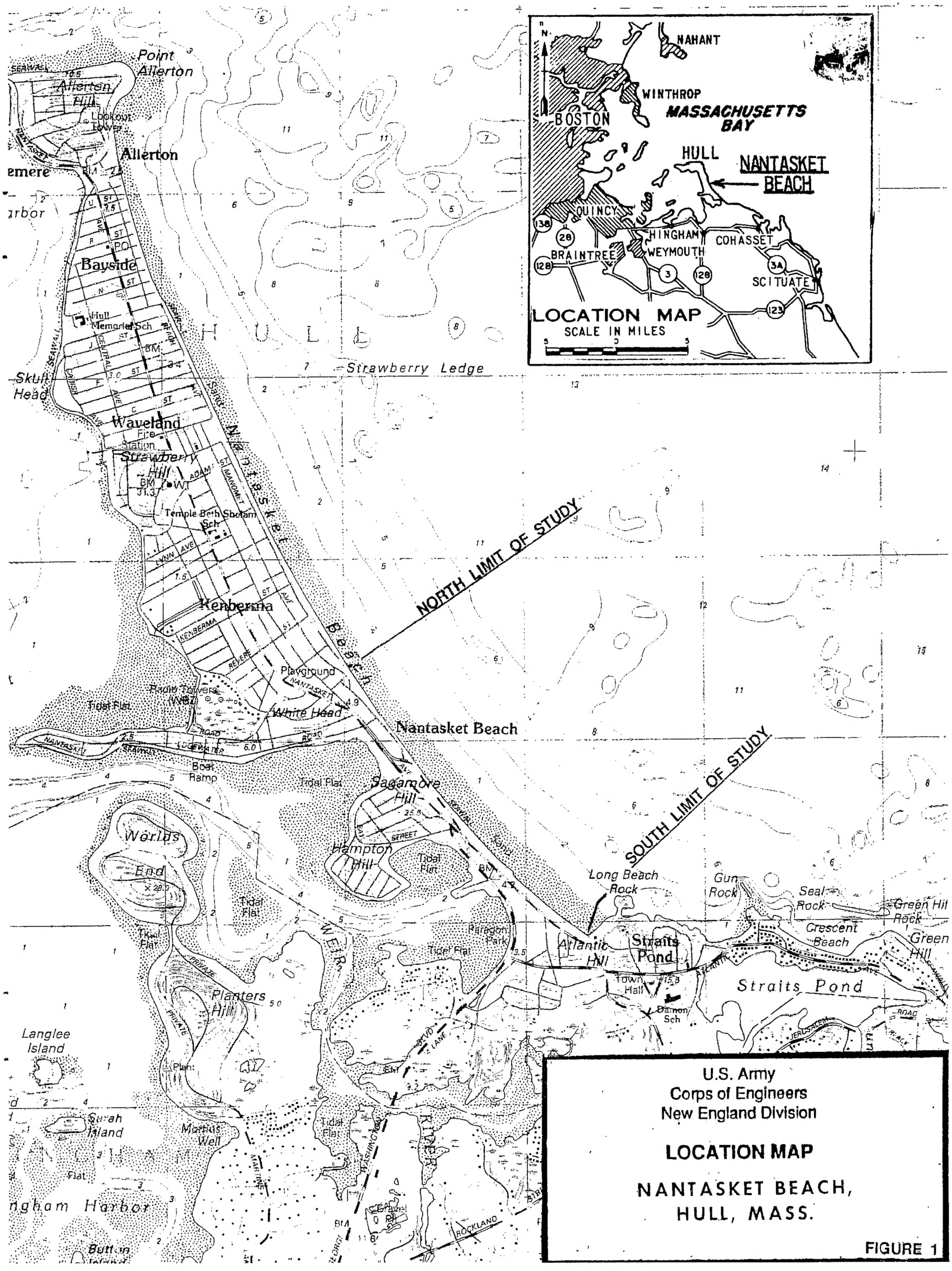
Damages that would occur in the study area if no project was constructed have been estimated, based on information supplied by the MDC and stage frequency curves prepared by the New England Division (NED) for the back shore area. Several potential improvement alternative plans to alleviate damages to the backshore structures were considered and one was examined in sufficient detail to provide a preliminary cost-benefit analysis. An environmental review for the area was performed.

PRIOR STUDIES AND REPORTS

Cooperative beach erosion control studies at Nantasket Beach have been made previously with the Metropolitan District Commission. The first report by the Division Engineer on Nantasket Beach was submitted to the Chief of Engineers on June 1, 1949. The report stated that Nantasket Beach was stable and recommended that the problem of maintenance of the beach for recreational use be accomplished by local interests entirely at their own expense by burying and covering stone deposits or by removal of stones and replacing them with equal volumes of sand.

The second report by the Division Engineer on Nantasket Beach was submitted to the Chief of Engineers in March 1968. The report concluded that the most practical and economical method of protection and restoration of the beach is to provide for beach widening by placement of suitable sand fill along about 6,800 feet of beach fronting the Metropolitan District Commission Reservation to a general backshore elevation of 17 feet above mean low water, thus furnishing a recreational and protective beach width averaging 190 feet behind the mean high water line. The project was subsequently authorized by Congress in December 1970. However, due to a lack of local cooperation, the project was never constructed and it was subsequently de-authorized in January 1990.

In addition to these Corps reports, a report entitled "Evaluation of Coastal Protection Measures at Nantasket in Hull, Massachusetts, Volumes 1 and 2, was prepared for the Disaster Recovery Team, Commonwealth of Massachusetts, by the Water Resources Division, Environmental Planning Division, Camp Dresser and McKee, Inc. (CDM), June 30, 1980. This report summarizes damages from the February 1978 blizzard to both the study area and North Nantasket Beach. Most of the report focuses on the residential area located north of the study area. The CDM report discussed the type of damages incurred from the storm, the damage costs, and recommended some measures for coastal protection from overtopping at the north end of the spit. It did not recommend any measures for coastal protection for the MDC reservation area.



U.S. Army
Corps of Engineers
New England Division

LOCATION MAP

NANTASKET BEACH,
HULL, MASS.

FIGURE 1

PHYSICAL SETTING

Nantasket Beach is located in the town of Hull, Plymouth County, Massachusetts, about 4 miles southeast of the main entrance to Boston Harbor and 12 miles southeast of the City of Boston. The MDC reservation is on the northeast side of a narrow tombolo formed when, following the most recent glaciation in the region, a spit tied the bedrock of the Atlantic Hill section of Hull to several drumlins such as Strawberry Hill and Allerton Hill. The entire spit is 17,000 feet in length with the study area comprising the southerly 6,800 feet and North Nantasket Beach the northerly 10,000 feet. The tombolo is 500 feet wide in the study area. The spit faces the Atlantic Ocean to the northeast and encloses Hull Bay on the southwest.

The sand comprising the present spit was derived from marine erosion of several drumlins in the area, many of which have been completely worn away. The several drumlins still existing are protected in a variety of ways from marine erosion, thus prohibiting any significant future natural replenishment of sand to the spit.

Analysis of shoreline change maps along the entire length of the spit shows the position of the mean high water line (MHW) to have both advanced and retreated over the period of record. According to the 1968 Corps of Engineers report cited previously there has been no significant net change in the position of the MHW over the past century. The 1968 report does not, however, relate the position of the MHW to sea level rise which is estimated at one foot over the past 100 years, and which is assumed to continue at least at the same rate for the next several decades.

Beach profiles reveal slopes that vary from 1:10 at the seawalls to flat slopes of 1:30 to 1:90 below the MHW in the study area. The beach is composed of light brown fine sand. The median grain size is about 0.25 mm with cobbles present on the backshore near the wall. The mean tidal range is 9.4 feet. Mean low water is 4.5 feet lower than NGVD.

The alignment of the spit is such that the dominant high energy waves from the northeast strike the beach with little or no long shore transport component. The nature of this alignment, the general morphology of the area and field observation strongly suggest that there is little net littoral drift occurring in the area.

The observations stated above as well as the position of the parallel offshore contours to the 30 foot depth contour approximately 3,000 feet offshore, indicate a relatively stable area extending from the backshore 3,000 feet out to sea and extending along the entire length of the spit. Within this cell typical seasonal changes will occur but there will be little overall net natural erosion or accretion under normal circumstances.

Removal of stones and cobbles from the beach by town and state agencies may have contributed to some net lowering of the beach as reported in the 1968 Corps of Engineers report. Storms, usually occurring in the winter season, carry fine materials out to sea from the beach leaving behind a lag deposit of stones and pebbles These are most evident in late winter and early spring. In order to "improve" the beach from a recreational standpoint a program of large scale removal of the stones and cobbles was initiated in the 1950's. A consultant to the MDC recommended in 1973 that similar stone be restored to the beach and that sufficient sand fill be placed in order to bring the beach back to the pre-cobble removal condition. The 1968 Corps of Engineers report concluded that lack of a sand source for natural replenishment together with the manual removal of material from the beach are factors which contributed to the loss of recreational beach at high tide in the study area.

PROBLEM DEFINITION

With the continuing loss of sand fill in front of the concrete seawalls and substantial lowering of the beach elevation the walls are now experiencing significant damage and undermining due to wave and tidal action. Overtopping of the walls and flooding of the backshore is now occurring with greater frequency during less intense storms than was the case in the past. Several sections of the concrete wall have already toppled over. If no alternative solutions are found to protect the concrete walls and reduce the overtopping and backshore flooding, the possibility exists that the walls will be lost completely along with the backshore roadway and a breach may ultimately occur in the spit at the northern portion of the study area thus isolating about two-thirds of the town on Hull's land area and its population from the mainland.

ENVIRONMENTAL SETTING AND RESOURCES

The beach in front of the seawall and riprap in the area of the MDC reservation is composed of light sand with pockets of cobbles located up against the concrete walls. The seawalls and riprap protect a public area located immediately behind the seawalls consisting of parking areas, a bathhouse, and a pavilion. Further back are Hull Shore Drive and Nantasket Avenue. Nantasket Avenue provides the sole access to the northern two-thirds of Hull's land area and its population. The backshore is composed of small seasonal commercial businesses such as: restaurants, an arcade, souvenir shops, a grocery store, a hardware store, as well as single family residences and a large apartment building at the south end.

The area is designated as a public beach according to the Massachusetts Coastal Zone Management Plan (CZM 1977). An intertidal sand flat is located directly offshore from the beach. No dunes or seagrasses were observed in the project area during the most recent site visit conducted on March 4, 1993.

As a result of the lack of sand in the backshore area, the upper beach areas are currently unstable and are mostly underwater during the higher portions of the tidal cycle. These shifting sands provide little, if any, suitable substrate for biota to colonize. No dunes or seagrasses or significant environmental resources were observed within the intertidal area during a cursory site inspection. However, no formal biological sampling program has yet been carried out.

Numerous fragments of surf clams were observed within the beach area. Initial coordination has revealed that subtidally, a commercially harvestable surf clam population exists offshore. Lobsters are also harvested in the offshore waters.

PLAN FORMULATION

Water resources planning undertaken by Federal agencies is directed by the Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. The economic and environmental principles contained in these guidelines relative to plan formulation were followed in this report so as to adhere to the Federal objective of contributing to the National Economic Development consistent with protecting the National environment. Various alternative plans were formulated in a systematic manner with a view toward enhancing national economic development and protecting environmental quality. Each of the several plans formulated were evaluated taking into consideration the four criteria of completeness, effectiveness, efficiency and acceptability.

STATEMENT OF PROBLEM

A significant amount of damage and undermining is being experienced by the concrete seawall and riprap that fronts the MDC Reservation due to wave and tidal action. During the recent past this situation has worsened due to the substantial loss of beach material and the lowering of the beach elevation in front of the seawall. The loss of beach material in turn has increased the amount and frequency of wave overtopping and backshore flooding. This shore damage and flooding is expected to continue and intensify in the future if no protective measures are taken. This section of the report will offer evidence in support of this problem statement, will describe the magnitude of the problem, and will discuss possible alternative proposals to alleviate the problem.

WITHOUT PROJECT CONDITION

Since the early 1970's, the backshore concrete seawalls, ramps, stairs, walkouts, riprap and sidewalks along the MDC reservation have been experiencing a gradual deterioration due to wave and tidal action, weathering, and abrasion. This situation has worsened during the past few years as a result of the increased erosion of beach

material in front of the seawall with the subsequent lowering of the beach elevation. The absence of any structured maintenance and repair program by the MDC over this time period has further contributed to the severity of the problem.

As a result, the area was very vulnerable at the time the "Halloween Storm" of October 30-31, 1991 occurred. The storm caused a substantial amount of structural damage to the concrete walls, ramps, stairs and riprap along with the erosion of a large volume of beach material. Approximately 350 feet of the wall experienced undermining and 370 feet of the wall was determined to be in need of replacement. At the time, the MDC estimated that about $1,100,000 in immediate structural repairs were needed.

Due to the extensive undermining and damage that occurred to the seawalls and erosion of beach material, the MDC, in a letter dated January 6, 1992, requested the New England Division to reactivate the previously authorized project. However, based on the critical nature of the situation, a decision was made to conduct this Reconnaissance Study under the authority contained in the Section 103 of the 1946 Flood Control Act, as amended, that is administered under the Corps Continuing Authorities Program.

Since the time of their letter, the MDC has not been able to put out a contract to make the immediate repairs that were needed. Subsequently, on December 11-12, 1992 another northeast storm hit the area and a 400 foot section of the concrete seawall at the north end of the beach tipped over. Emergency repairs have been made at a cost of about $1,000,000.

During both the October 1991 and December 1992 storms, the walls were overtopped and the backshore roadways were flooded. Some minor flooding also occurred to the backshore commercial establishments. However, for the most part the flood waters just ran down the roadways and emptied into the Bay without causing any substantial damage.

If permanent repairs and protection measures are not implemented very soon, the backshore facilities and roadway are in danger of being lost. If the situation is allowed to continue, it may ultimately result in a breach in the spit that could cutoff the northern portion from the mainland.

For this study, the project area has been broken down into two damage areas. The first includes all the land, structures and facilities within the MDC Nantasket Beach Reservation including the beach itself. The second includes the backshore roadways, private residents and commercial structures. The backshore has been further divided into three damage zones as shown on Plate D-2 in Appendix D. Those zones are defined by street elevations and temporary ponding areas noted during a site visit during the December 1992 storm. It is believed that each zone acts independently to convey flood waters into the bay area.

The MDC has provided information relative to the cost of past damages that have occurred and an estimate of the cost of future damages that may occur if no permanent protection measures are implemented. This information was used to estimate the annual damages that would be prevented in the MDC reservation with a protection project in place. The details are shown in the Economic Justification Section of this report.

For the backshore damage zones 1, 2, and 3, a preliminary analysis has shown it is possible to design a protection project that will substantially reduce backshore flooding for storms up to a fifty year event. This determination is based on comparing the wave runup and overtopping that is occurring along the existing beach with that which would be experienced with a protection project in place. Stage frequency curves developed for interior flooding due to wave overtopping are contained in Appendix D.

In order to determine the top of runup and volume of overtopping that is currently occurring along the Nantasket Beach and that which would occur with a protection project in place, it was necessary to establish design parameters needed to compute wave heights and periods for various storm events.

Wind data from Logan Airport in Boston, that was presented in the General Design memorandum, Revere Beach Erosion Control Project, August 1985 (revised June 1986), was assumed to be applicable to the study area. The National Weather Service (NWS) has recorded 31 years of hourly one-minute average windspeed and direction data at Logan Airport from 1945 through 1979. A duration of 24 hours was selected for winds from the east-northeast having return periods of 2, 5, 10, 25, 50 and 100 years blowing over a fetch length of 400 miles during periods of fully developed seas. The design wave heights and periods that were calculated using these parameters are shown in Table 1.

TABLE 1
WIND GENERATED WAVES
NANTASKET BEACH, HULL, MASSACHUSETTS

Return Period (Yrs)	Duration (Hrs)	Wind Speed (MPH)	Fetch (MI)	Wave Height (Ft)	Wave Period (Sec)
100	24	39	400	24.1	14.3
50	24	37	400	22.2	13.7
25	24	34	400	19.4	12.8
10	24	29	400	15.2	11.3
5	24	27	400	13.6	10.7
2	24	21	400	6.6	7.5

On December 16, 1992, nine beach profiles were surveyed along 6,000 feet of Nantasket Beach and nine reaches were established for use in calculating existing overtopping volumes. (See Appendix D). A nearshore slope of 1 vertical to 50 horizontal was assumed, and wave heights for the various return periods noted above were adjusted for the wave to break at the toe of the structure. The results indicated that no overtopping would be experienced along the first 1200 feet at the north end of the beach or for about the first 350 feet at the south end for any of the return periods considered. However, all along the middle 5300 feet of beach, a fairly significant amount of overtopping is being experienced during the five year event and increases substantially as the intensity of the storms increase. The top of runup was calculated to be about twice as high as the top of the walls during the 100 year storm event. The following Table 2 shows this information in tabular form.

TABLE 2
EXISTING RUNUP AND OVERTOPPING CONDITIONS ALONG THE MIDDLE 5300 FEET OF NANTASKET BEACH

Return Period (Years)	Average Top of Wave Runup (feet above NGVD)	Average Height of Top of Wall (feet above NGVD)	Average Rate of Overtopping (CFS)
100	33.6	16.2	4900
50	31.6	16.2	4200
25	28.7	16.2	3200
10	24.2	16.2	1400
5	22.4	16.2	900
2	16.8	16.2	100

A similar set of calculations were made with a protection project in place. The results are shown in Table 3 in the Economic Justification Section of this report, along with a summary of the effectiveness of a protection project in reducing overtopping and backshore flooding as defined by the stage frequency curves shown in Appendix D.

SCREENING OF ALTERNATIVES

Measures addressing coastal shore/flood damage reduction fall into two general categories. Some modify the extent of shore damage/flooding by altering the natural environment; such as breakwaters, seawalls, revetments, etc. Others address shore/flood damage vulnerability through flood plain regulations, flood insurances, and flood proofing.

ALTERNATIVE/SHORE/FLOOD DAMAGE PREVENTION MEASURES

MODIFYING SHORE DAMAGE/FLOODING	REDUCE VULNERABILITY
Breakwaters	Floodproofing
Revetments	Flood Warning and Evacuation
Beach Restoration	Flood Insurance
Groins	

Below is a brief description and a summary of the study's findings for each type of measures investigated for Nantasket Beach.

Breakwaters

A breakwater is a structure that can serve to protect a shore area, harbor, anchorage or basin from wave attack. Beaches and flood prone areas along the coast can be protected by a structure that reduces the wave energy reaching the shore. Breakwaters are generally some variation of an offshore rubble stone mound structure, adaptable to almost any depth and can be exposed to severe waves.

Breakwaters can have both beneficial and detrimental effects on the shore. Offshore breakwaters are usually more costly than onshore structures, such as seawalls or revetments. The elimination of wave action not only provides protection but also reduces the movement of sand along the shore and thereby prevents the nourishment of the downdrift beaches.

The cost of a breakwater located offshore was found to be prohibitive, with an estimated cost far in excess of benefits to be derived. It was therefore dropped from further consideration in this study.

Revetments

Sloping revetments armor the seaward face of a shoreline with one or more layers of stone or concrete. This sloping protection dissipates wave energy, with a less damaging effect on the shore. Two types of structural revetments are used for coastal protection: the rigid, cast-in-place concrete type and the stone armor unit type.

On the negative side, revetments will displace the beach in front of the seawalls which is contrary to one of the study's objectives of protecting the values and qualities of the area's seaside location.

Like the breakwater, the cost of a revetment was found to be prohibitive, with estimated costs far in excess of benefits to be derived. Accordingly, it too was dropped from further consideration in the reconnaissance study.

Beach Restoration and Nourishment

Beaches are very effective in dissipating wave energy. When maintained to adequate design dimensions, they can afford protection for the adjoining backshore. When conditions are suitable, long reaches of shore may be protected by artificial nourishment. The resultant widened beach also has added value as a recreational feature.

This measure will be evaluated in more detail in subsequent pages of this report.

Groins

Groin structures are shore protection structures usually built perpendicular to the shoreline to trap longshore littoral drift or retard erosion of the shore. They can also be used in conjunction with artificial sand fill to compartmentalize the sand and keep it in place. The alignment of the shoreline at Nantasket Beach is such that the waves approach almost perpendicular to the shore and a majority of the sand losses are directly offshore. The use of groin structures at Nantasket Beach is not considered to be a viable method of trapping material or retarding erosion along the beach. It is therefore not going to be given any further consideration in this study.

Floodproofing

This encompasses several techniques for preventing damages due to floods, requiring action both to structures and to building contents. It involves keeping water out, as well as reducing the effects of its entry. Such adjustments can be applied by the individual, or as part of a collective action, either when buildings are under construction or during remodelling.

Floodproofing, like other methods of preventing flood damages, has its limitations. It can generate a false sense of security and discourage the development of needed flood control and other actions. Indiscriminately used, it can tend to increase uneconomical use of flood plains.

Floodproofing measures can be classified into three broad categories. First are permanent measures which become an integral part of the structure or land surrounding it. Second are temporary or standby measures which are used only during floods, both which are constructed and made ready prior to any flood threat. Third are emergency measures which are carried out during flood situations in accordance with a predetermined plan. In recent years, floodproofing has come to be known as a "nonstructural" measure. Structural measures are traditionally associated with major civil flood control works.

Typical nonstructural measures include closure for openings (doors, window, etc.), waterproof sealants for walls and floors, utility valves to prevent backflow of sewer and plumbing facilities, and sump pumps. Another technique is raising existing structures above design flood levels.

Within an existing group of structures, damageable property can often be placed in a less vulnerable location or protected in-place. Furnaces and appliances can be protected by raising them off the floor. Damageable property can be moved from lower to higher floors, or other less flood prone sites. Important mechanical and/or electrical equipment can be floodproofed by enclosing them in a watertight utility cell or room.

A consideration that must be included is that residual damage to both the structure and contents will remain even when the most vulnerable property is rearranged or protected. Measures such as these are usually considered when other measures are either not physically or economically feasible, or the depth of flood is relatively shallow.

Elimination of flood damages can also be accomplished by relocation of existing floodprone structures and/or contents. There are basically two options for removing property to a location outside the flood hazard area. One is to remove both structure and contents to a flood-free site; the second is to remove only the contents to a structure located outside the flood hazard area, and demolish or reuse the structure at the existing site.

A number of the above mentioned flood proofing measures have already been implemented by the owners of the backshore structures. They have proved effective during lesser storm events when flooding is kept below the first floor level. Floodproofing by itself does not provide a comprehensive solution that is acceptable to the public. Much of the loss that has been experienced in the project area has been as a result of damage to the seawall and appurtenant facilities. These structures cannot be floodproofed. Accordingly, floodproofing has not been selected for any further detailed evaluation.

Flood Warning and Evacuation

Flood forecasts, warning and evacuation is a strategy to reduce flood losses by charting out a plan of action to respond to a flood threat. The strategy should include:

- A system for early recognition and evaluation of potential floods.

- Procedures for issuance and dissemination of a flood warning.

- Arrangements for temporary evacuation of people and property.

- Provisions for installation of temporary protective measures.

- A means to maintain vital services.

- A plan for post flood reoccupation and economic recovery of the flooded area.

Flood warning is the critical link between forecast and response. An effective warning process will communicate the current and projected flood threat, reach all persons affected, account for the activities of the community at the time of the threat (day, night, weekday, weekend) and motivate persons to action. The decision to warn must be made by responsible agencies and officials in a competent manner to maintain the credibility of future warnings.

An effective warning needs to be followed by an effective response. This means prompt and orderly evacuation and/or action.

This includes:

- Establishment of rescue, medical and fire squads.

- Identification of rescue and emergency equipment.

- Identification of priorities for evacuation.

- Surveillance of evacuation to insure safety and protect property.

The town of Hull does not have a structured flood warning and evacuation plan. However, prior to and during severe storm events, the town officials alert the residents on the local cable station. They are provided with general guidance as to necessary actions they should take and places they could evacuate to if necessary.

The town should consider developing a formal flood warning and evacuation plan to include the following:

- Development of a flood warning system.

- Determination of safe evacuation routes.

- Provisions of adequate emergency shelters.

- Methods to provide vital services.

However, warning and evacuation alone do not prevent widespread flooding and the physical damage it brings. Accordingly, flood warning and evacuation has not been selected for any further detailed evaluation in this report.

Flood Insurance

Flood insurance is not really a flood damage reduction measure: rather it provides protection from financial loss suffered during a flood. The National Flood Insurance Program was created by Congress in an attempt to reduce, through more careful planning, annual flood losses and to make flood insurance protection available to property owners.

The program provides local officials with a usable tool in protection of their flood plains. A flood-prone community, once on the regular program, must enact flood plain zoning in accordance with minimum guidelines established by the Federal Emergency Management Agency (FEMA). Hull is such a community and they have adopted appropriate flood plain zoning regulations.

Without implementation of a flood damage reduction system, the financial losses associated with flooding will continually be a burden. It is not economical, nor wise for the government, both State and Federal, to continually provide assistance. Personal assets are limited. Like other flood plain regulations, use of flood insurance is encouraged. However, it also does not reduce the physical damage and social disruption caused by a flood. Since all new development would be required to elevate at or above the base flood (an event having a 1 percent chance of occurrence annually), and because of the extent of existing development, further study of flood insurance is not appropriate.

Sand Fill Protection Project

Based on preliminary studies accomplished in the reconnaissance phase the protection project involving placement of sand fill along approximately 6,800 feet of beach fronting the MDC reservation to a general backshore elevation of 17 feet above mean low water has been determined to be cost effective and warrants more detailed evaluation in the Feasibility Study Phase.

Starting at the seawall the project would provide for a 75 foot wide level beach berm at elevation 17 feet above mean low water. From here the beach face would then slope seaward with a slope of 1 vertical (V) to 15 horizontal (H) until it intersects the existing ground. This would then provide a protective beach averaging 190 feet in width behind the mean high water line (see plates 1-10).

Based on existing conditions, some sections of the seawall along the middle portion of the beach are experiencing overtopping during storm events that occur as often as every two years. The amount of overtopping increases substantially during more intense storm events with return periods between 5 to 100 years. (See Appendix D).

With the beach fill project in place, the waves will break farther offshore and runup the face of the beach. The berm elevation of 17 feet above mlw will not be overtopped by storm waves having a 50 year return frequency or less. During more intense storm with return frequencies of up to 100 years, if the beach is in place and at its full design dimensions, overtopping of the backshore wall will be substantially reduced. (See Appendix D). However, if the storm continues in intensity over several tide cycles and the beach erodes back to any significant extent, the amount of overtopping will increase accordingly.

Topographic surveys and profiles conducted as part of the reconnaissance study were used as the basis to estimate volumes of sandfill necessary to construct the beach to the proposed design dimensions noted above. Survey measurements show that 465,000 cubic yards of sand are necessary for the protective beach. A preliminary material source survey has shown that suitable beach fill can be obtained from a land-based borrow pit within a 35 mile radius of the beach. Based on a recent experience with the sand fill at Revere Beach it is anticipated the material will have a median diameter of between 0.4 to 0.5 mm which is about twice that of the native material This coarser material will be more resistant to the erosive forces in the area and thus reduce annual losses that have been experienced in the past. The annual nourishment requirements are based on historic records with an adjustment for a more stable beach fill.

At an estimated cost of $6.90 per cubic yard, the first cost of the beach fill project is estimated to be $4,220,000 including contingencies, engineering and design and construction management. The project cost including future nourishment, based on historic records, is estimated at $5,590,000 million. A more detailed financial analysis of the project cost is presented in Table 5.

ECONOMIC JUSTIFICATION

The reconnaissance level economic analysis compared damages that would occur to the concrete seawall and backshore structures with the cost of the beach fill protection project alternative put forth in this study. The damage figures are based on information provided by the Metropolitan District Commission regarding their seawall and backshore facilities and estimates of interior flood damages from waves overtopping the walls that were experienced during the October 30-31, 1991 storm, based on stage frequency curves shown in Appendix D.

The existing concrete seawalls that extend along the shoreline of the Metropolitan District Commission (MDC) Nantasket Beach Reservation in Hull were constructed in stages starting in 1915 and extending through 1938. The MDC currently estimates that the walls have a replacement value of $12,880,000.

During recent times, a substantial amount of beach material has been eroded from in front of the seawalls to the extent that some of the footings are now exposed and in other areas the walls are being undermined. As a result during the December 11-12, 1992 coastal storm a 400 foot section of wall collapsed at the north end of the beach. Emergency repairs were made to the wall at a cost of about $1,000,000.

The MDC estimates that under existing conditions they would need to expend $2,679,000 annually to make needed repairs to maintain the integrity of the walls. This is based on their estimate that they would be required to replace about 1120 feet of wall annually. This represents one-fifth of the total length of walls.

As noted earlier in the report, flood damages to the backshore during the October 30-31, 1991 storm were not severe. Only a few structures experienced any first floor flooding. Most of the flood damages occurred to vehicles, landscaping and basements. Damages recurring from an event of this magnitude are estimated to be $100,000.

Project benefits result from the reduction in damages to the seawall and the reduction in flooding damages to the backshore that could be attributed to the project. Damage reduction benefits are equal to the difference between damages with and without the project in place. In addition to these protection benefits, the project will also increase the amount of recreational beach area available for use by the general public during all stages of the tide. These benefits are not currently included in the economic analysis, but they will be evaluated in the Feasibility Phase of the study.

With the project in place to its full design dimensions, the future damages to the seawalls are expected to be minor. Thus, the annual project benefits for seawall damage reduction are estimated to be $2,679,000.

As was noted in the Without Project Condition Section of the report, runup calculations were prepared with the beach project in place for the various return periods and design wave heights shown in Table 1. The results are shown in Table 3 below.

TABLE 3
TOP OF AVERAGE WAVE
RUNUP ALONG THE PROPOSED PROTECTIVE BEACH
WITH A SLOPE OF IV:15H

Return Period (Yrs)	Top of Average Wave Runup (feet above NGVD)	Average Height of Top of Wall (feet above NGVD)	Average Rate of Overtopping (CFS)
100	17.3	16.2	1100
50	16.6	16.2	500
25	15.7	16.2	3
10	14.3	16.2	----
5	13.6	16.2	----
2	11.1	16.2	----

There are currently five commercial structures in Zone 1 located in the 100 year floodplain; 26 commercial structures and five residential structures are located in the 100 year floodplain in Zone 2; and there are 24 commercial buildings and 21 residential buildings in the 100 year floodplain in Zone 3. Using the stage frequency curves in Appendix D, the expected annual flood damages by zone for the existing conditions are:

Zone 1	$ 400
Zone 2	35,200
Zone 3	70,600
	106,200

Backshore project benefits are derived from reduction in flooding damages provided by the project. Therefore annual flood damage estimates were developed both with and without the project in place. The difference in damage estimates by zone with and without the project in place which equal the projects benefit are shown below.

Zone	Without Project Damages	With Project Damages	Project Benefits
1	$ 400	$ 0	$ 400
2	35,200	11,000	24,200
3	70,600	37,000	33,600
TOTAL	$106,200	$48,000	$58,200

Table 4 below provides a summary of project benefits.

TABLE 4
SUMMARY OF ANNUAL PROJECT BENEFITS

TYPE		AMOUNT
Seawall Damage Reduction		$2,679,000
Backshore Flood Damage Reduction		58,200
	TOTAL	$2,737,200

The total first cost of construction is estimated to be $4,220,000 as noted in Table 5. When this cost is annualized at 8-1/4% over a 50 year project life and annual nourishment costs are added, the total annual project costs are estimated to be $374,500. When the annual benefits are divided by the annual costs, the benefit cost ratio is 7.1 to 1. Reducing the benefits from the avoided seawall damages by 50 percent results in a benefit-cost ratio of 3.6. Thus the proposed project has sufficient economic justification for proceeding to the Feasibility Study Phase.

For more information of the economic analysis see Appendix C.

TABLE 5
SUMMARY OF PROJECT COSTS

(A) Estimated Implementation Costs
(1993 Price Level)

- Scheduled Construction Costs		
Sandfill 465,000 cy x $6.90/cy		$3,208,500
Contingencies (25%)		802,000
	SUBTOTAL	$4,010,500
Planning, Engineering & Design		60,000
Construction Management		149,500
		$4,220,000
- Unscheduled Construction Costs		
Sandfill/Renourishment		
4,000 cy/year x 49 years x $7/cy		1,370,000
- Total Estimated Implementation Cost		$5,590,000

- Cost Sharing of Estimated Implementation Costs

	Fed 3/	Non-Fed	Totals
Preauthorization Studies	$ 225,000	$ 100,000	$ 325,000
Scheduled Construction Cost	1,775,000	2,445,000	4,220,000
Unscheduled Construction Cost	-0-	1,370,000	1,370,000
TOTALS	$2,000,000	$3,915,000	$5,915,000

(B) Economic Data
(8-1/4% 50 Year Life)

Annual Charges 1/	$ 383,000
Annual Benefits 2/	$2,737,200
Benefit - Cost Ratio:	7.1

(C) Non-Federal Requirements:

LERRD		
Cash		
Reimbursements		$3,915,000
	TOTALS	$3,915,000

The issue of how the non-Federal sponsor will meet the obligations for sharing in the implementation costs of the project will be addressed during the feasibility phase.

(D) Cost Allocation

The proposed project has the sole purpose of reducing storm damage and flooding during coastal storms.

(E) Federal Allocation to Date

Reconnaissance Study	$125,000

(F) Remaining Federal Requirements:

- Feasibility Phase	$ 100,000
- Implementation Costs Including P&S	$1,775,000

(G) Total Federal Investments: $2,000,000

1/ Annual Charges
- Scheduled Construction Costs
$4,220,000 x .08409 (Int & Amort @ 8-1/4% for 50 years) =

$ 355,000

- Unscheduled Construction Costs (Nourishment is estimated on an average annual basis. It will, however, be carried out after several years of erosional loss).

4,000 cy/year x $7/cy = 28,000
$383,000

2/ See Table 4 for the derivation of the annual benefits.

3/ The Federal share of implementation costs for projects resulting in public benefits due to storm damage reduction is 65% including reconnaissance and feasibility costs. The Federal costs respectively of the reconnaissance and feasibility studies are $125,000 and $100,000 for a total of $225,000. Section 103 of Public Law 87-874, as amended, however, imposes a $2,000,000 limit on overall Federal expenditure, including preauthorization studies.

REAL ESTATE REQUIREMENTS

There is only one ownership potentially involved in the land required for the proposed shore protection and flood damage reduction project. The land is a public beach and is owned by the Commonwealth of Massachusetts, under the jurisdiction of the Metropolitan District Commission. There are no potential Public Law 91-646 relocations. No real estate interest needs to be acquired for a shore protection and flood damage reduction project at Nantasket Beach.

ENVIRONMENTAL CONCERNS

An assessment of the environmental impacts from the sand fill alternative plan considered for Nantasket Beach are summarized below.

Under the "no action" alternative the concrete seawalls and riprap revetment would continue to be damaged and overtopped causing flooding to the backshore area. Sandfill in front of the seawall would continue to erode. From an environmental standpoint the existing environment and impacts will remain as is.

Environmental concerns as they relate to project implementation would lie with the potential for impact to the commercially harvestable populations of the surf clam and lobsters. Prior to project construction and in preparation of the Environmental Assessment, it will be necessary to quantify, through a formal sampling program, the existing benthic and shellfish resources that may inhabit the area. Should sufficient numbers of these individuals be at risk, a relocation plan may be implemented which would temporarily remove existing resources to unaffected areas and then repopulate the stabilized area upon completion of the work.

ENVIRONMENTAL FINDINGS

Initial coordination with Federal, State and local agencies have revealed no outstanding or unreasonable environmental issues. The reconnaissance investigations described above conclude that impacts to the surf clam population are expected to be minor. No Federal or State threatened, endangered, or rare species are known to exist in the project area.

The proposed project could possibly impact prehistoric or underwater archaeological resources, which may be in the vicinity of the project area. There are approximately twenty-seven (27) documented shipwrecks that may be located in the vicinity, as well as, at least eight (8) prehistoric archaeological sites which are known within the Hull area. Floodproofing measures which may be performed on historic homes near the proposed project area, could also impact significant resources. However, this is a preliminary investigation, and if this project proceeds to a further stage in the planning process, then formal comments will be requested from the Massachusetts State Historical Preservation Officer to satisfy Section 106 of the National Historic Preservation Act. In a letter dated November 27, 1992, the Massachusetts Historical Commission concurred with these determinations.

CONCLUSIONS

The shore damage to the concrete seawalls and riprap revetment and backshore flooding problems at Nantasket Beach in Hull, Massachusetts has been studied and alternatives to alleviate these concerns have been formulated. Based upon reconnaissance level engineering, economic and environmental study and review of the problem a solution has been developed and with the support of the MDC, the New England Division, Corps of Engineers, finds sufficient benefits will accrue to the MDC and town of Hull, to warrant a more detailed study.

Federal policy guidelines state that the reconnaissance phase of a study consists of all work and analysis required to determine whether there is an interest in Federal planning and to obtain necessary agreements with the local sponsor. These requirements have been met by this report. The local sponsor has agreed to the Feasibility Cost Sharing Agreement and the Scope of Services as detailed in the next section of this report.

RECOMMENDATIONS

The Division Engineer recommends that authority and appropriations be delegated to pursue the Section 103 Feasibility Phase Study for Nantasket Beach, Hull, Massachusetts. This feasibility study will be cost shared on a 50/50 basis with the MDC.

25 AUGUST 1993
Date

Brink P. Miller
Colonel, Corps of Engineers
Division Engineer

DESCRIPTION OF FEASIBILITY PHASE STUDIES REQUIRED

The Feasibility Phase will entail in-depth environmental, engineering and economic evaluations of the alternate plans described above, each in such detail as is required to first select the best plan and then to develop its specifics. The product will be a Detailed Project Report (DPR). If a positive recommendation is forwarded, the DPR will be the basis for preparation of Plans and Specifications. In Section II of this report, Appendix A, the Scope of Studies, delineates the required tasks to be performed during this phase and details the cost of each task. Appendix B summarizes the feasibility study cost estimate. Appendix C discusses the cost sharing of the feasibility phase.

ACKNOWLEDGMENTS

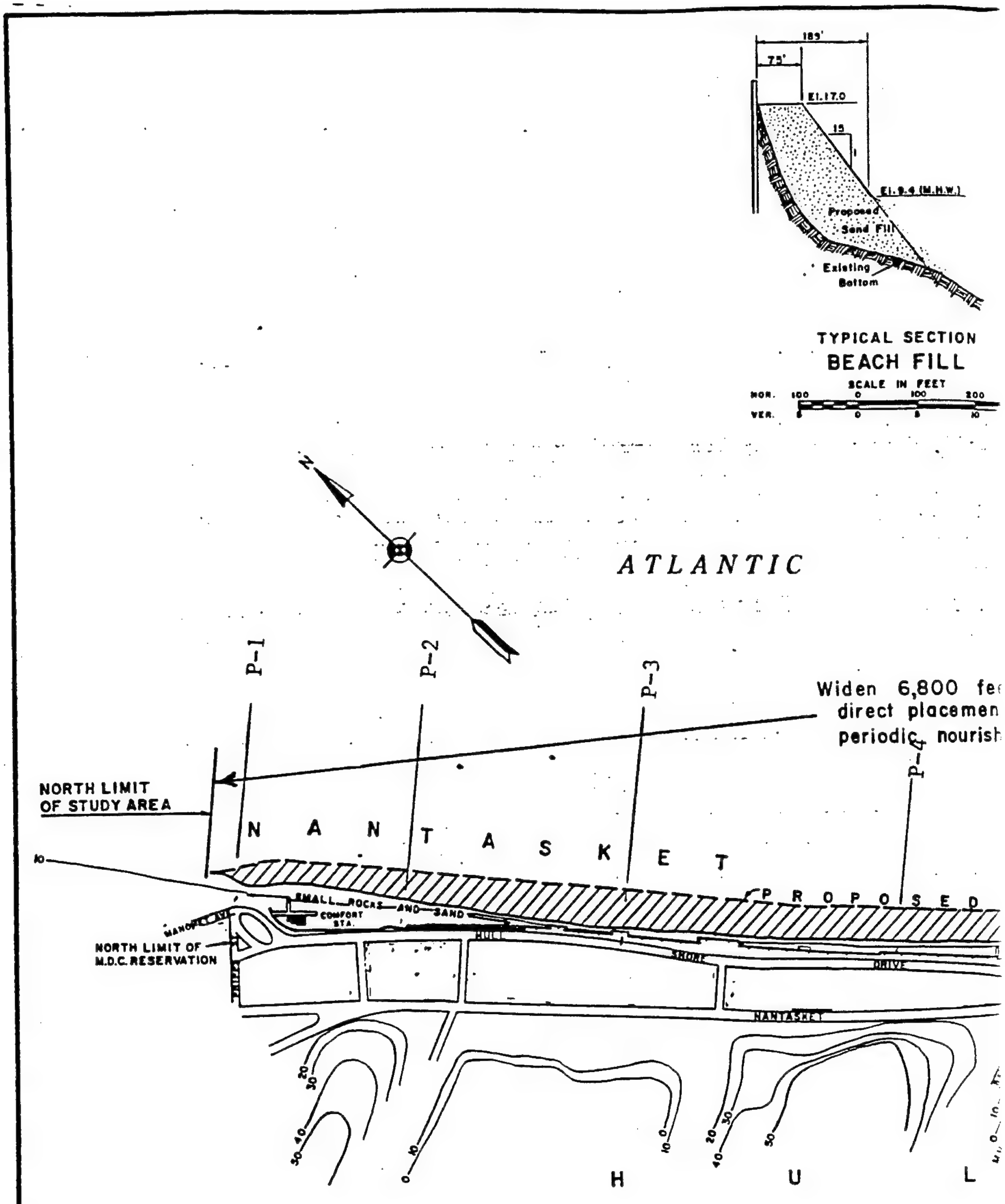
The New England Division, U.S. Army Corps of Engineers prepared this report under the direction of Colonel Brink P. Miller, Division Engineer. It was prepared by Mr. William T. Coleman, Project Manager, under the supervision of Mr. John T. Smith, Chief, Coastal Development Branch, Mr. Paul E. Pronovost, Chief, Plan Formulation Division and Mr. Joseph L. Ignazio, Director of Planning.

Members of the Study Team include:

Mr. Ed O'Leary - Economic Analysis
Mr. Mark Paiva - Historic Properties
Mr. Jay Mackay - Environmental Considerations
Mr. Bob Meader - Coastal Engineering
Mr. Bob Simeone - Geotechnical Engineering
Mr. Dan Stenstream - Geotechnical Engineering
Mr. Tony Siegel - Cost Engineering
Ms. Carmen Suarez - Hydrologic and Hydraulic Analysis
Ms. Ulrika Volz - Hydrologic and Hydraulic Analysis
Ms. Maureen McCabe - Real Estate
Mr. Ed Fallon - Real Estate

This report was prepared for publication by Ms. Kathy Bucciarelli and Mr. Edward Madigan.

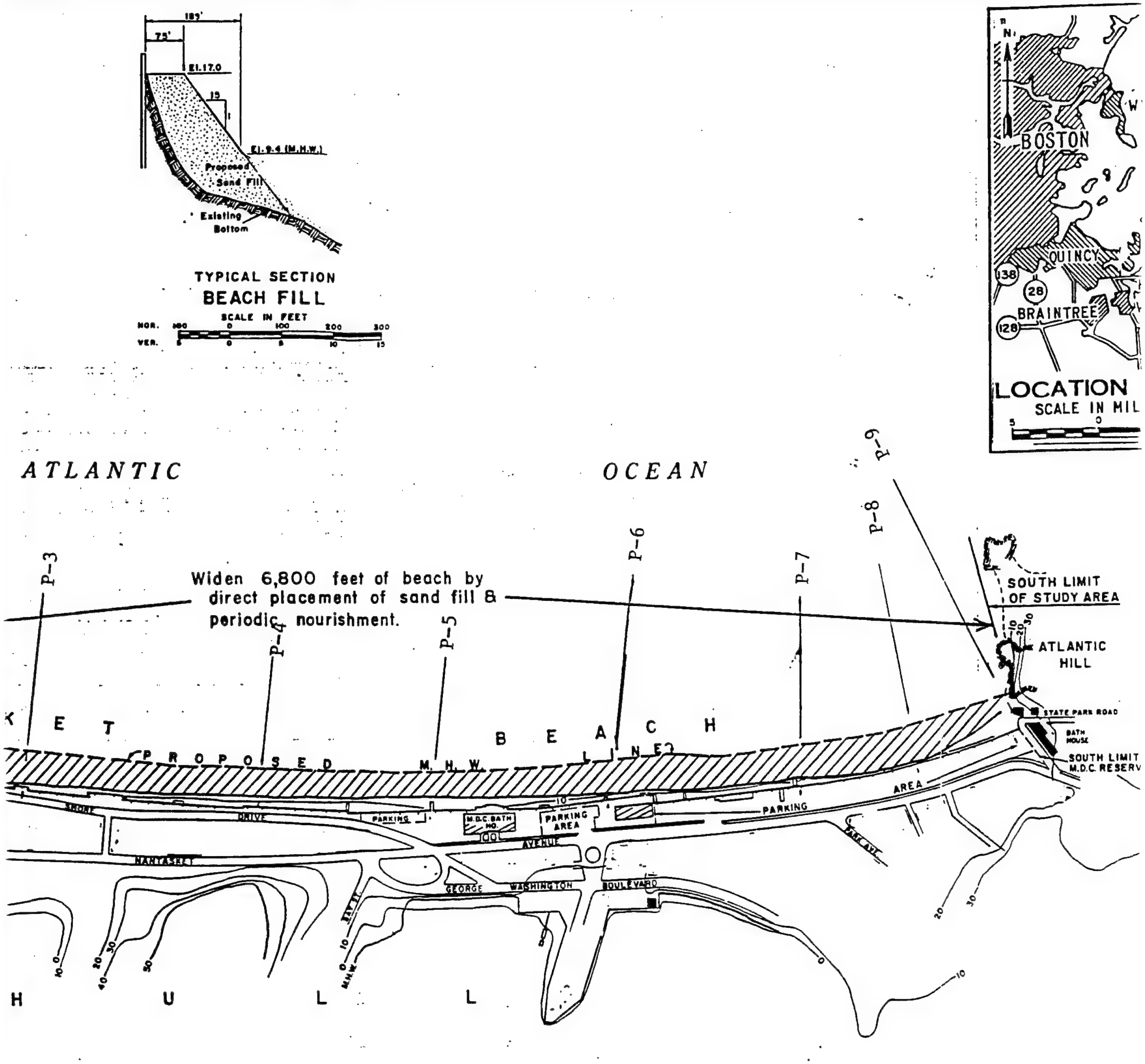
Special thanks are extended to Mr. Carnie Terzian and Mr. Henry Higgott of the Metropolitan District Commission whose cooperation and assistance proved invaluable during the course of this study.



NOTES

Location of Profiles Taken in December
Shown Thus P-1

1



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of Profiles Taken in December 1992
P-1

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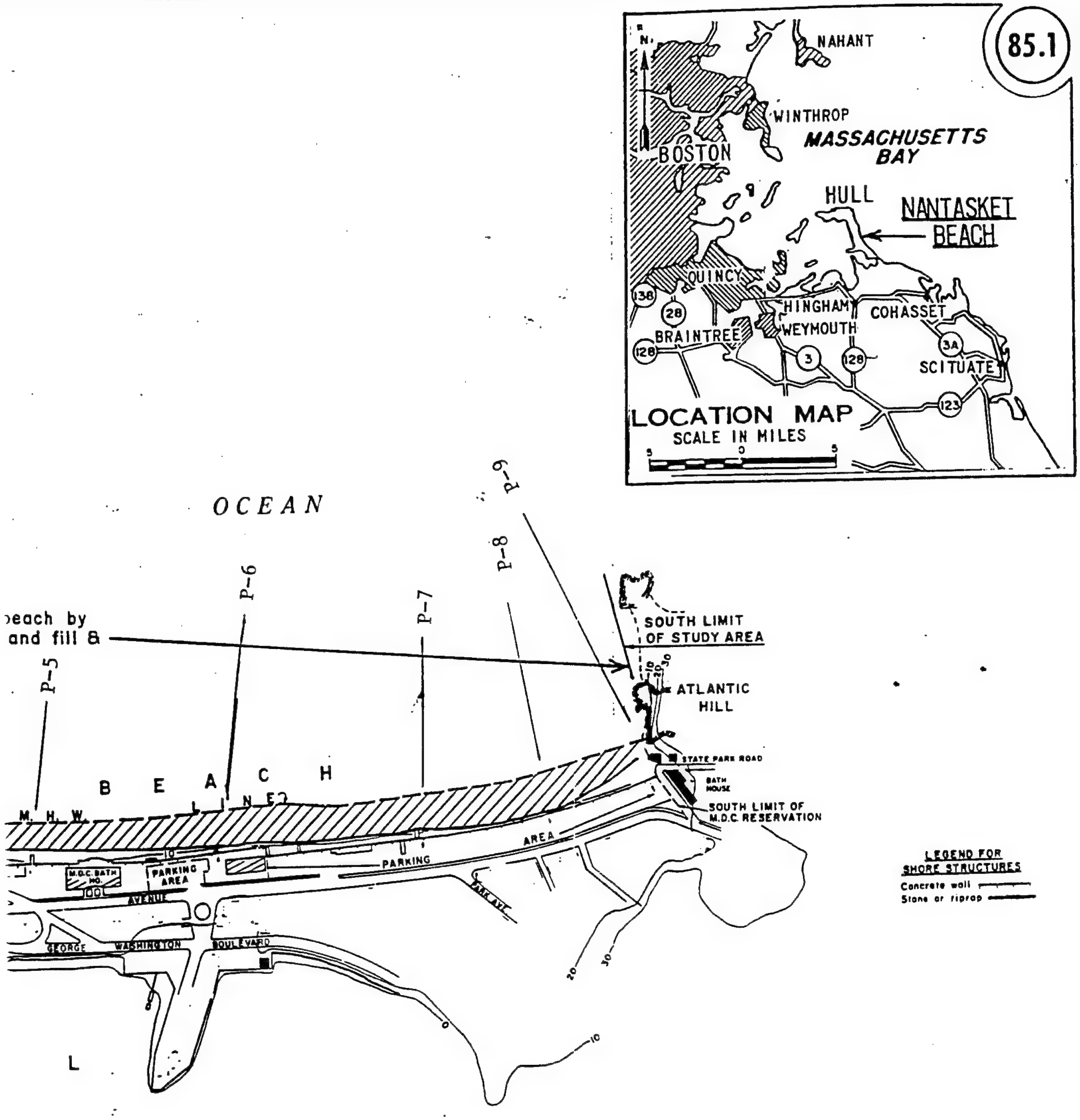

NANTASKET BEACH,
HULL, MASS.

SCALE IN FEET

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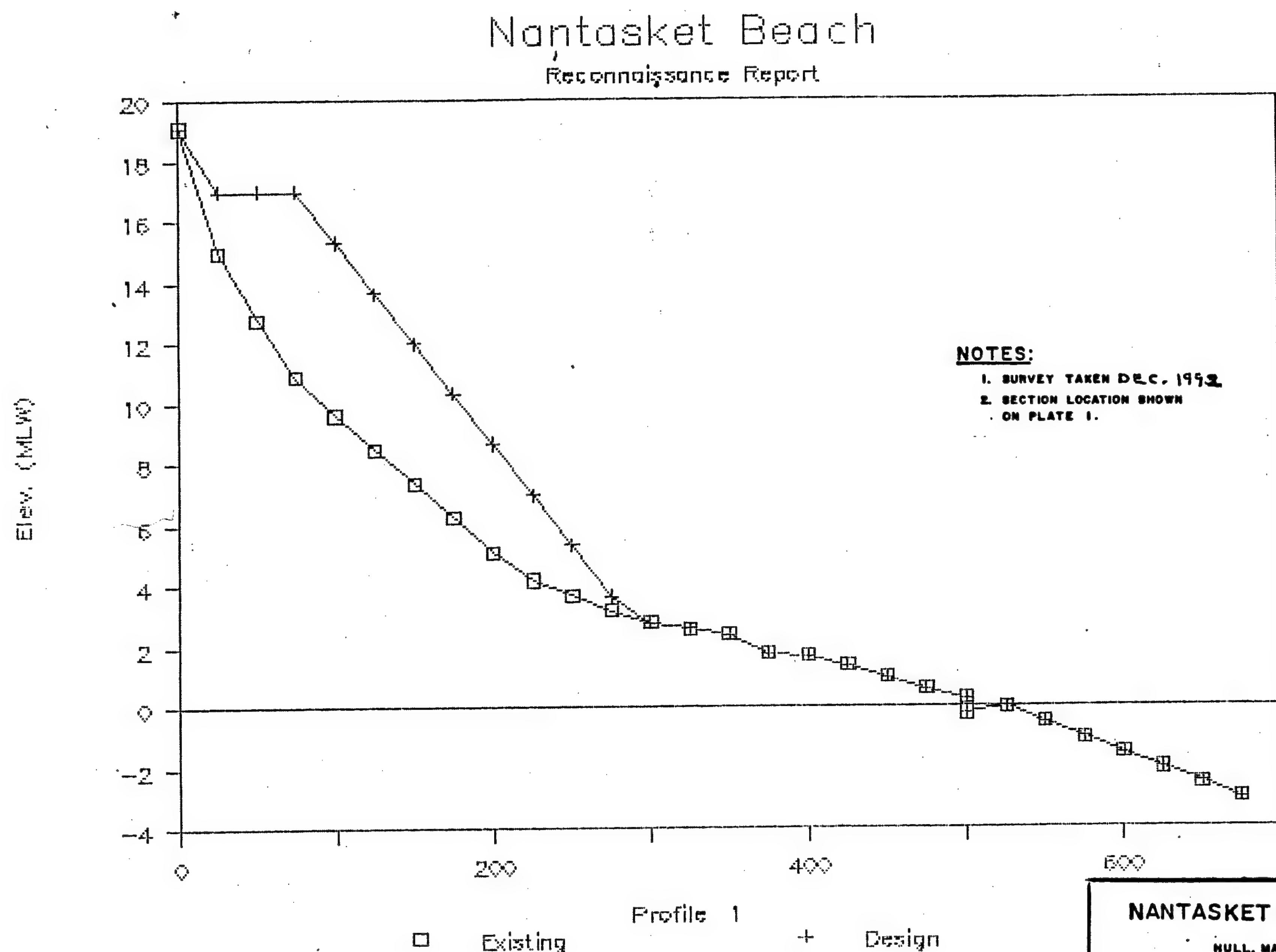
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.



NANTASKET BEACH STUDY

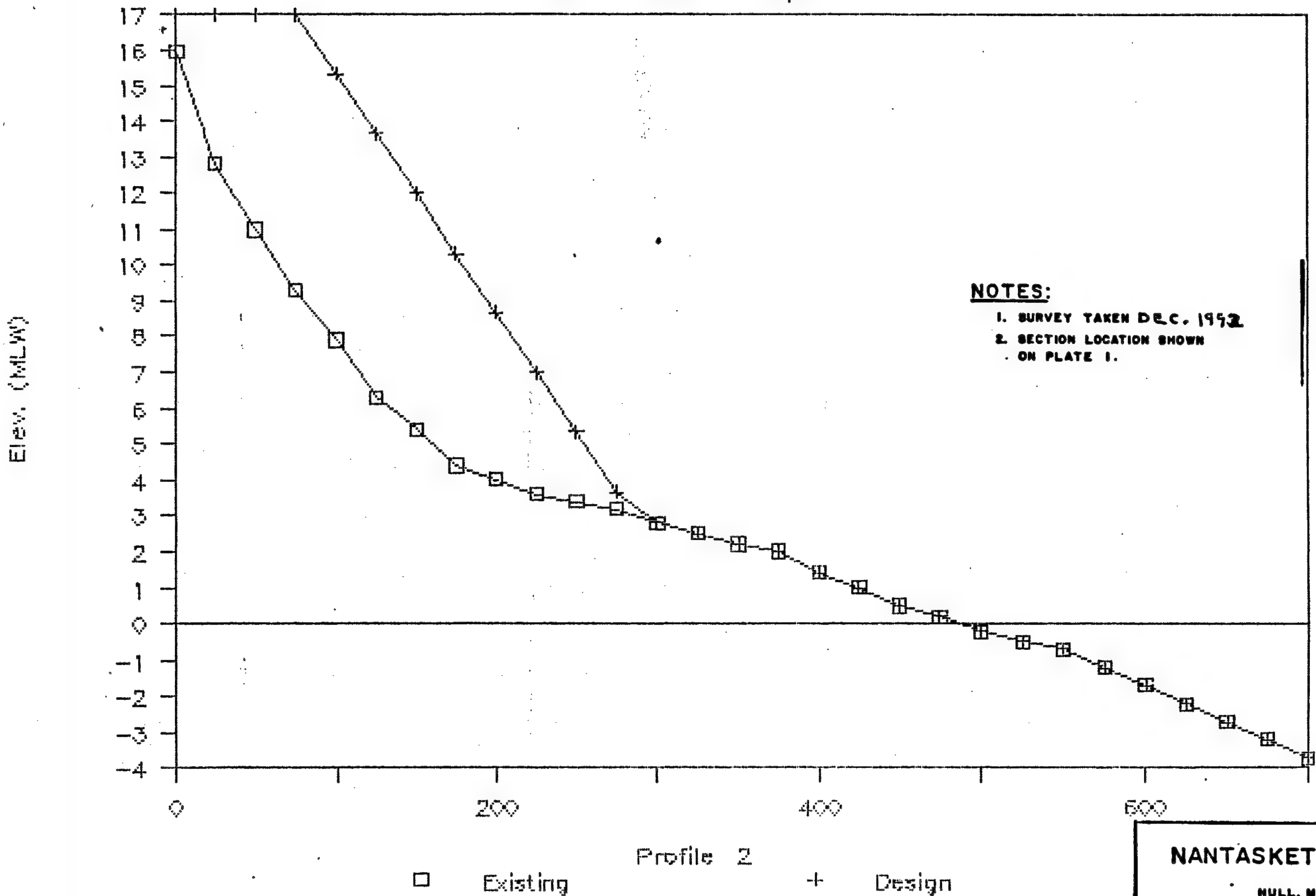
HULL, MASSACHUSETTS

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

PLATE 2

Nantasket Beach

Reconnaissance Report



NANTASKET BEACH STUDY

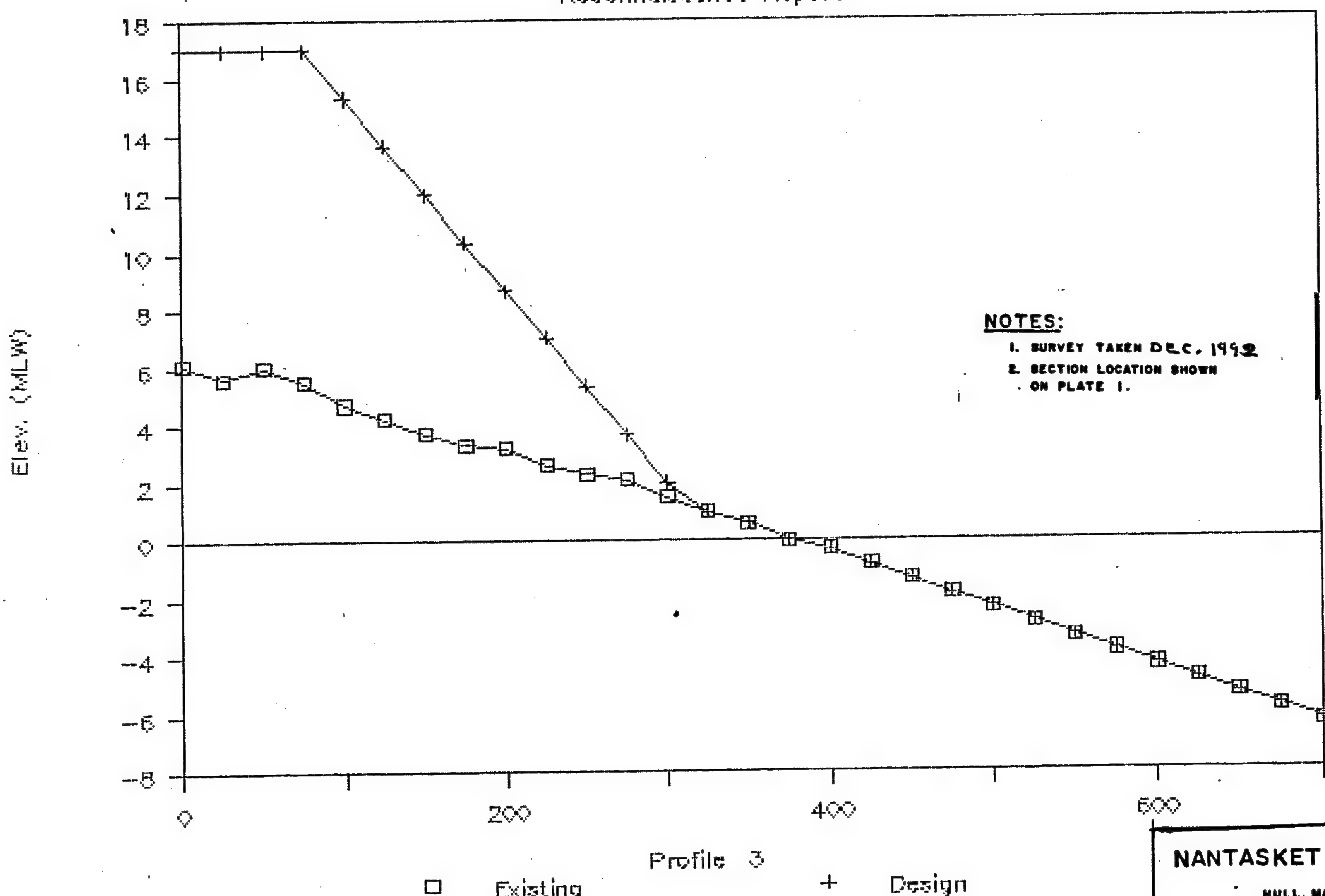
HULL, MASSACHUSETTS

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

PLATE 3

Nantasket Beach

Reconnaissance Report

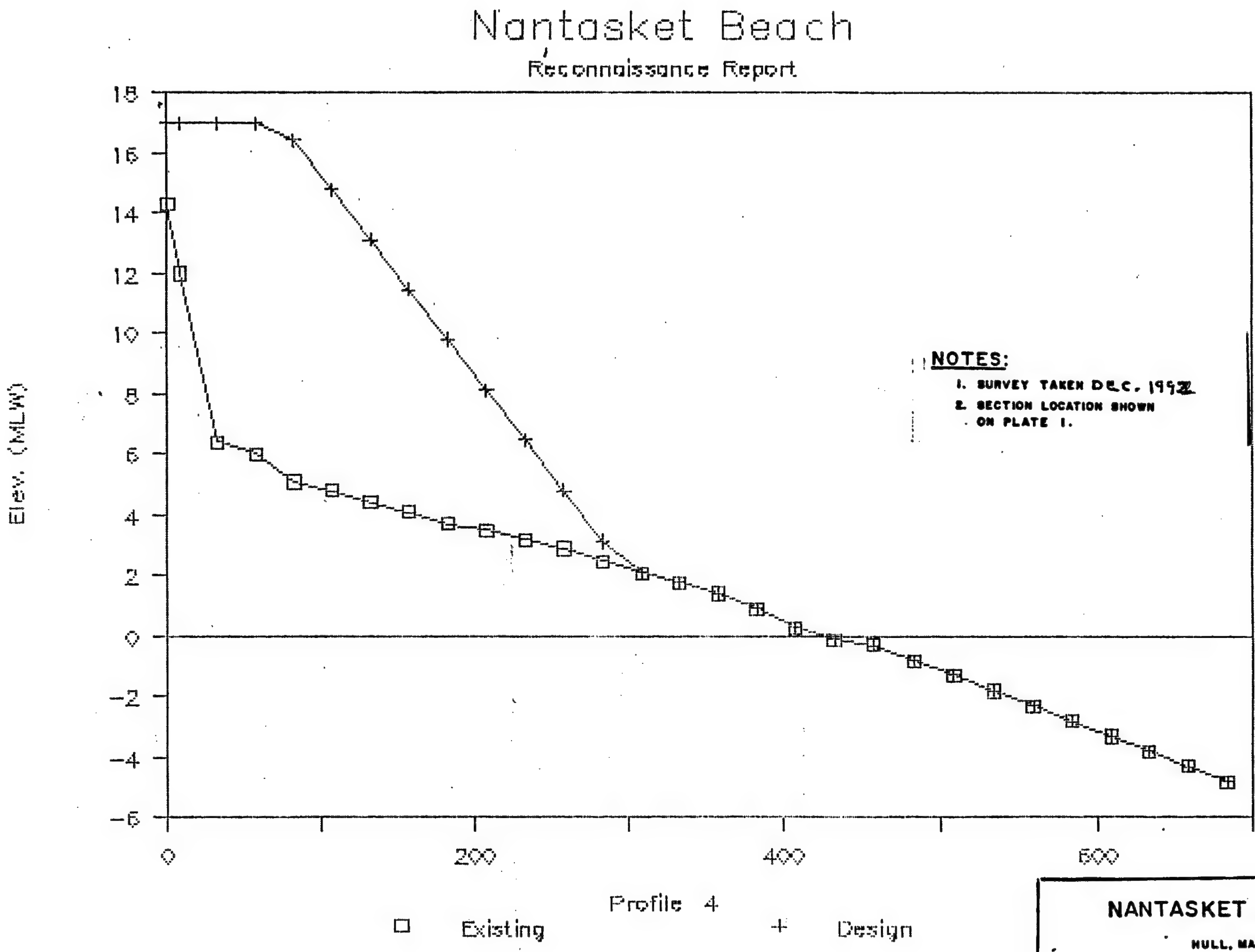


NANTASKET BEACH STUDY

HULL, MASSACHUSETTS

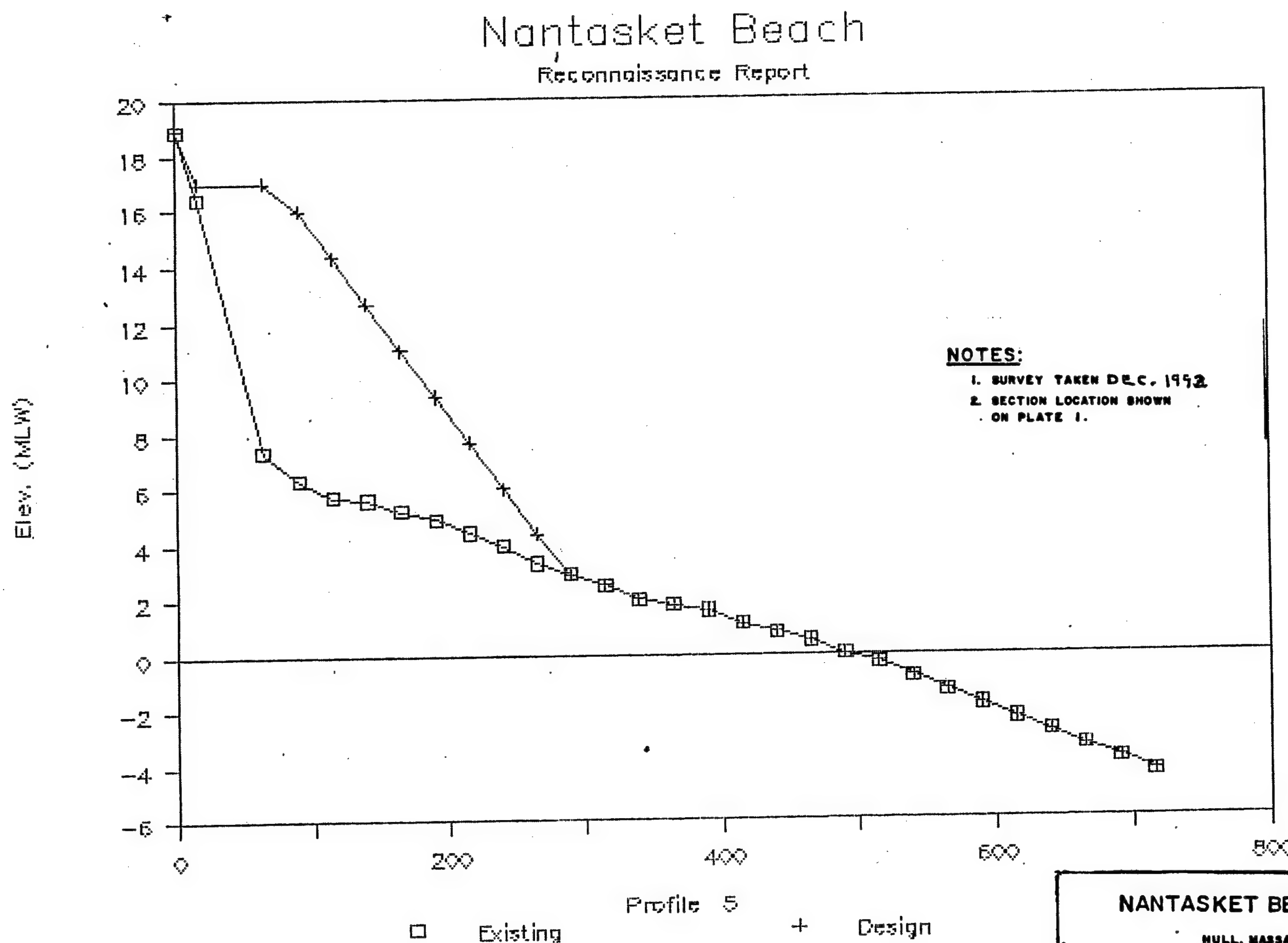
NEW ENGLAND DIVISION, CORPS OF ENGINEERS

PLATE 4



NANTASKET BEACH STUDY
HULL, MASSACHUSETTS
NEW ENGLAND DIVISION, CORPS OF ENGINEERS

PLATE 5



NANTASKET BEACH STUDY

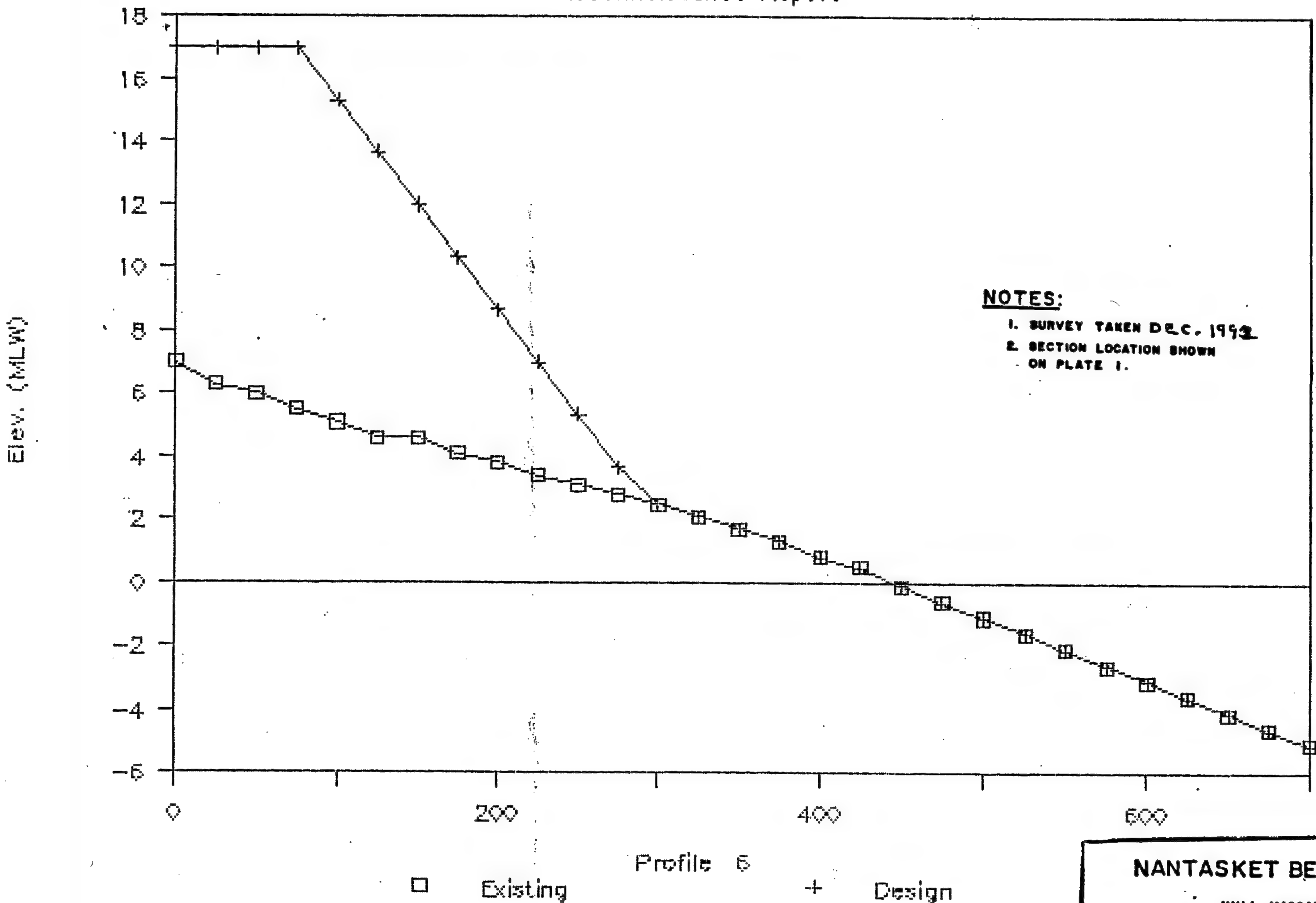
HULL, MASSACHUSETTS

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

PLATE 6

Nantasket Beach

Reconnaissance Report

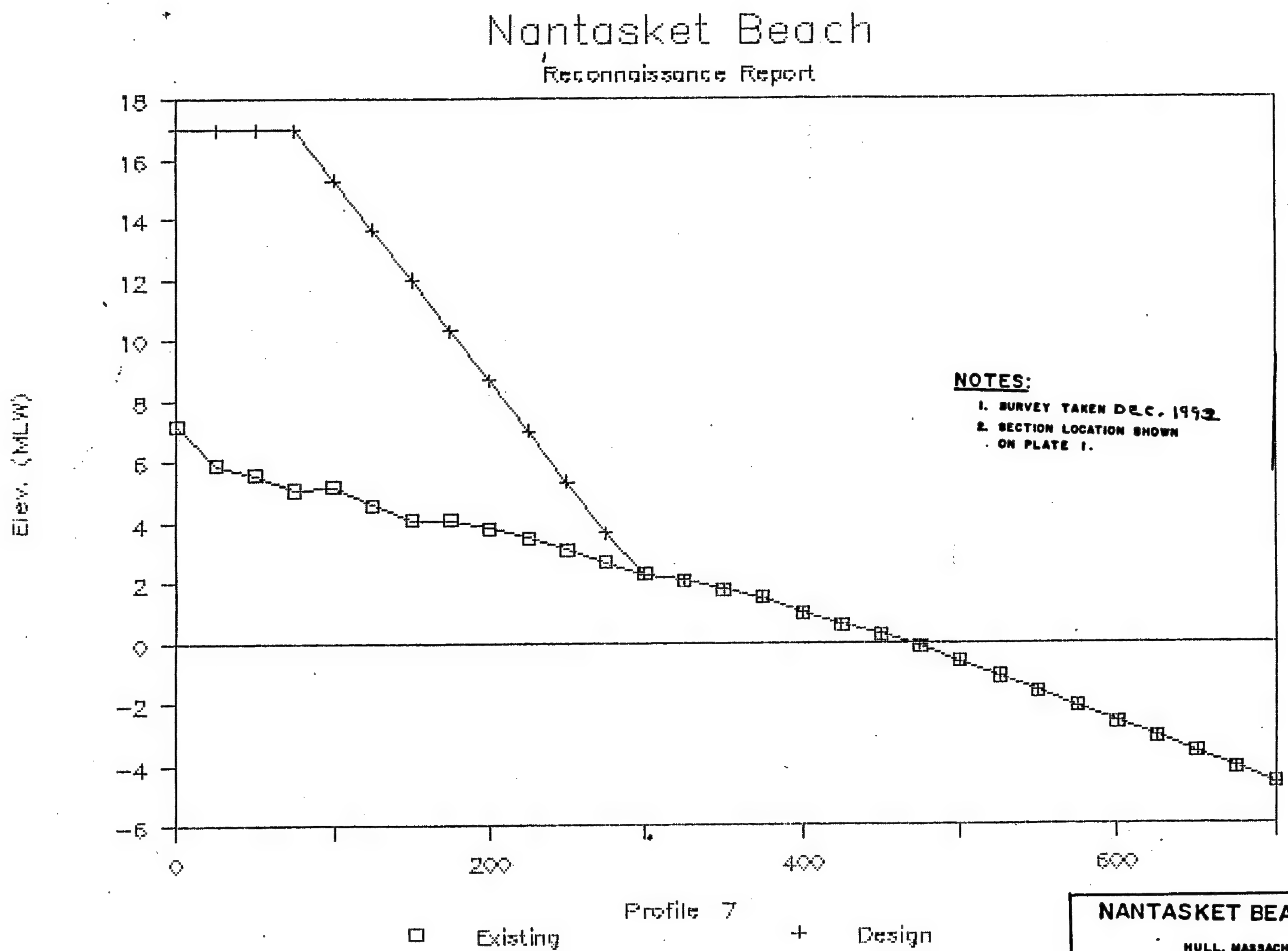


NANTASKET BEACH STUDY

HULL, MASSACHUSETTS

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

PLATE 7

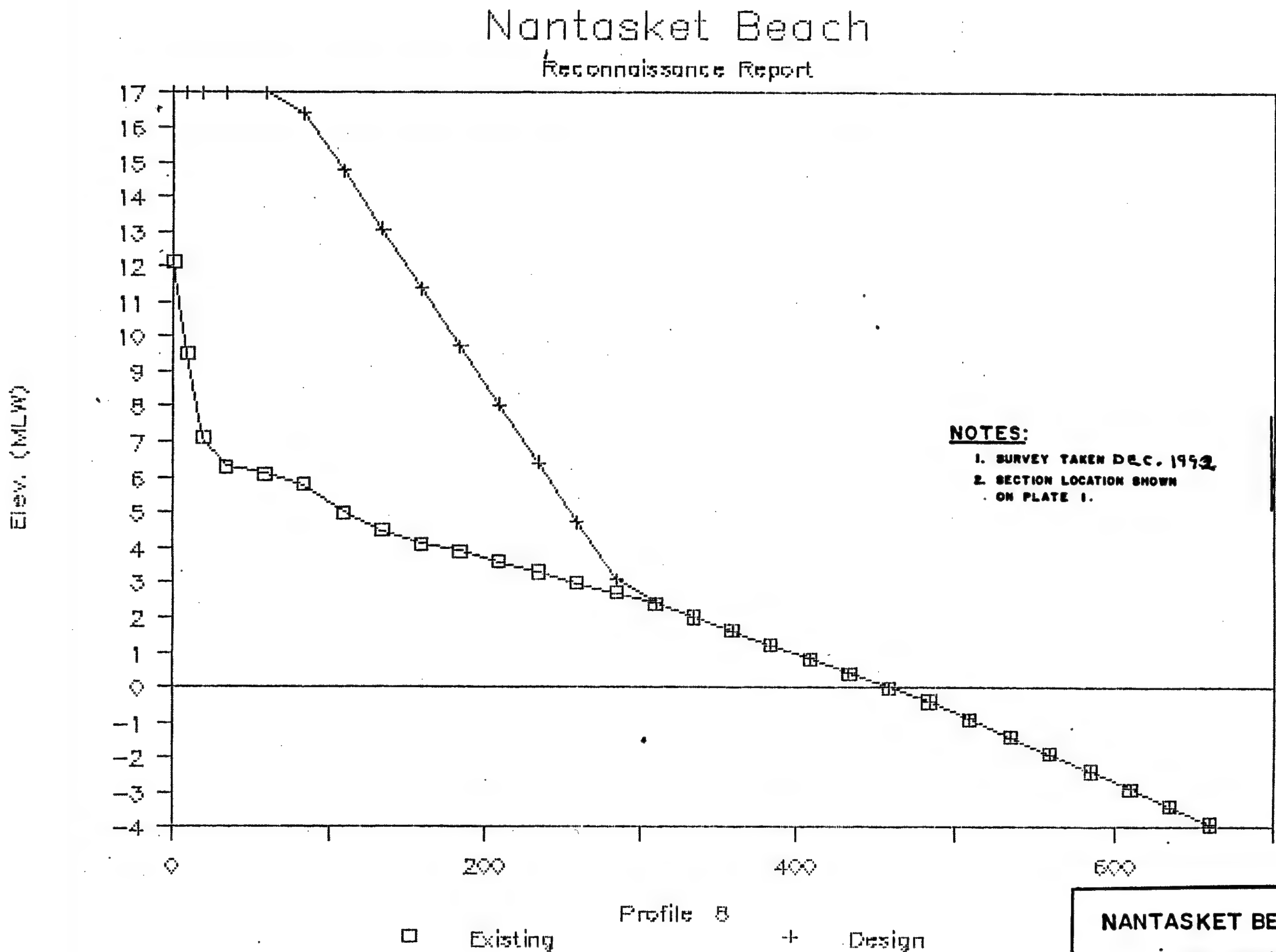


NANTASKET BEACH STUDY

HULL, MASSACHUSETTS

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

PLATE 8

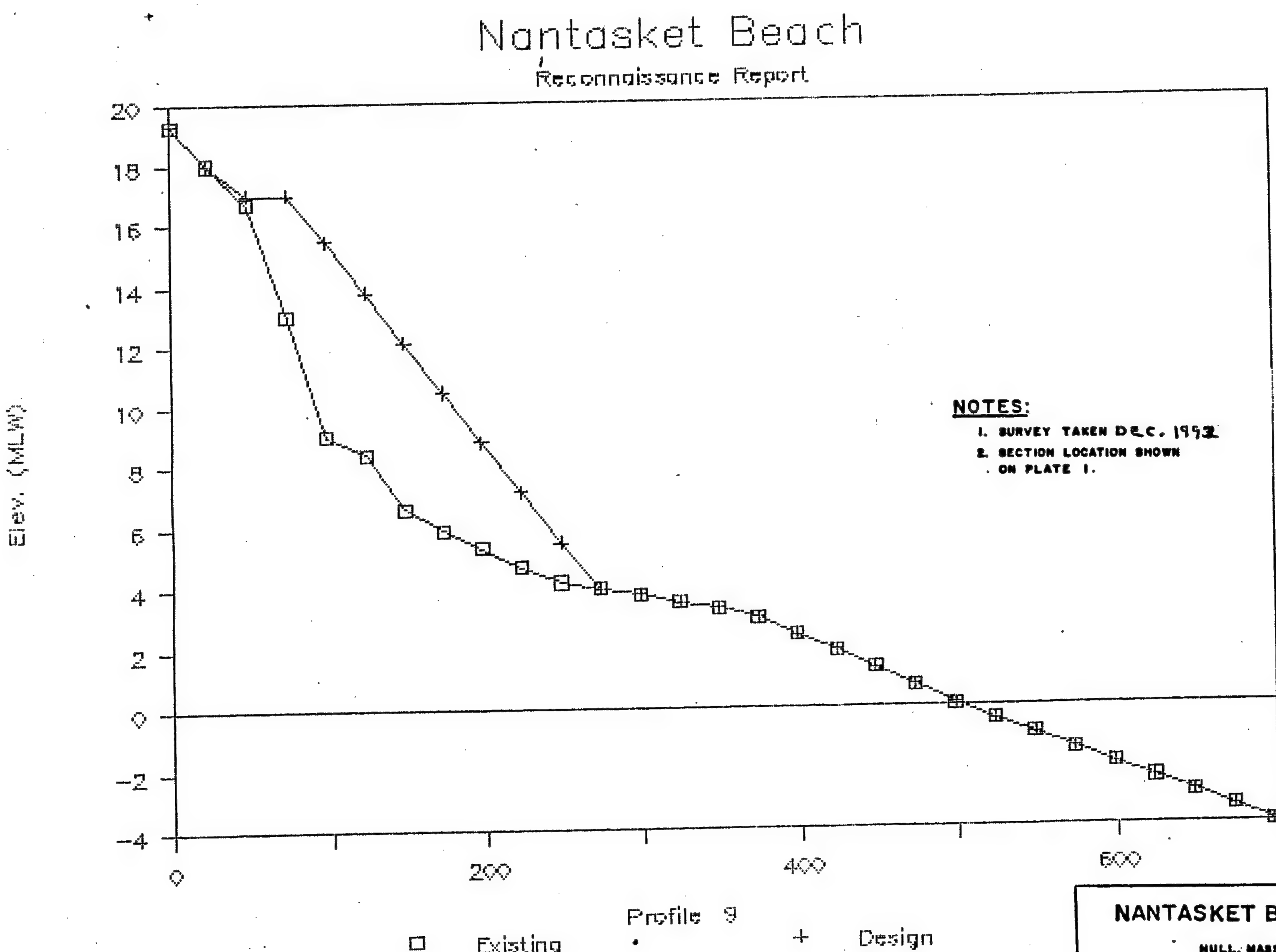


NANTASKET BEACH STUDY

HULL, MASSACHUSETTS

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

PLATE 9



NANTASKET BEACH STUDY

HULL, MASSACHUSETTS

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

PLATE 10

SECTION II

FEASIBILITY COST SHARING AGREEMENT

Updated: 2 December 93

D R A F T

FEASIBILITY COST SHARING AGREEMENT

COST SHARING AGREEMENT
BETWEEN THE UNITED STATES OF AMERICA
AND
THE COMMONWEALTH OF MASSACHUSETTS
FOR THE
NANTASKET BEACH COASTAL SHORE PROTECTION
FEASIBILITY STUDY

THIS AGREEMENT, entered into this _______ day of____________, 199 by and between the United States of America (hereinafter called the "Government"), represented by the Contracting Officer executing this Agreement, and the Commonwealth of Massachusetts (hereinafter called the "Sponsor"), acting by and through its Metropolitan District Commission,

WITNESSETH, that

WHEREAS, the Congress has authorized the Corps of Engineers to conduct studies of shore erosion problems pursuant to the continuing authority provided by Title I, Section 103, 74' Stat. 484, 33USC426: and

WHEREAS, the Corps of Engineers has conducted a preliminary study of shore damage and flooding caused by waves impacting and overtopping backshore concrete walls at Nantasket Beach, Hull, Massachusetts, hereinafter referred to as the "Reconnaissance Phase Study", pursuant to this authority, and has determined that further study in the nature of a "Feasibility Phase Study" (hereinafter called the "Study") is required to fulfill the intent of the study authority and to complete the determination of the extent of the Federal interest in alleviating potential shore damage and backshore flooding; and

WHEREAS, the Sponsor has the authority and capability to furnish the cooperation hereinafter set forth and is willing to participate in Study cost sharing and financing in accordance with the terms of this

Agreement; and

WHEREAS, the Sponsor considers it in its best interest to have the Study promptly completed, and is willing to contribute fifty (50) percent of the total Study Cost to facilitate its prompt completion; and

WHEREAS, the Sponsor and the Government both understand that entering into this agreement in no way obligates either party to implement a project and that whether a project is supported for authorization and budgeted for implementation depends upon the outcome of this Feasibility Study and whether the proposed solution is consistent with the Principles and Guidelines and with the budget priorities of the Administration and that at the present time, favorable budget priority is being assigned to projects providing primarily commercial navigation and flood or storm damage reduction outputs; and

WHEREAS, the Water Resources Development Act of 1986 (P. L. 99-662) specifies the cost sharing requirements applicable to the Study;

NOW THEREFORE, the parties agree as follows:

ARTICLE I - DEFINITIONS

For the purpose of this Agreement:

a. The term "Study Cost" shall mean all disbursements pursuant to this Agreement, whether from Federal appropriations or from funds made available to the Government by the Sponsor, and all negotiated costs of work performed by or contracted for by the Sponsor pursuant to this Agreement. Such costs shall include, but not be limited to: labor charges; direct costs; overhead expenses; supervision and administration costs; and contracts with third parties, including termination or suspension charges; and any termination or suspension costs (ordinarily defined as those costs necessary to terminate ongoing contracts or obligations and to properly safeguard the work already accomplished) associated with this Agreement. Additionally, the "Study Cost" includes a Review Contingency equal to the lesser of five (5) per centum of the "Study Cost" or $10,000, such amount to be used in the event of work required as a result of Division or Headquarters level review. Any review costs which exceed this amount or that are incurred after the end of the decision document study phase will be borne entirely by the Federal Government.

b. The term "Study Period" shall mean the time period for conducting the Study commencing when funding from both the Sponsor and the Federal Government is available for expenditure following the execution of this Agreement and ending with the Chief of Engineers' acceptance of the Study.

c. The term "Negotiated Cost" is the cost of a work item, accomplished other than by contract, to be accomplished by the Sponsor as an in-kind service.

ARTICLE II - OBLIGATIONS OF PARTIES

a. The Sponsor and the Government, using funds contributed by the Sponsor and appropriated by the Congress, shall expeditiously prosecute and complete the Study currently estimated to be completed in 18 months from the commencement of the Study Period (Article I b. above), substantially in compliance with Article III herein, and in conformance with applicable Federal and state laws and regulations, the "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies" and mutually acceptable standards of engineering practice.

b. The Government and the Sponsor shall each provide, in cash, contracts, and in-kind services, fifty (50) percent of all Study Costs, which Study Cost is currently estimated at $200,000, as specified in Article IV herein; provided, that the Government shall, as specified in Article V herein, periodically give credit against cash contributions required of the Sponsor for any Study Costs of the Sponsor as documented under Article V (d) herein; provided further, the Government shall not obligate any cash contribution by the Sponsor toward Study Costs until such cash contribution has actually been made available to it by the Sponsor.

c. No Federal funds may be used to meet the Local Sponsor share of study costs under this Agreement unless the expenditure of such funds is expressly authorized by statute as verified by the granting agency.

d. The award of any contract with a third party for services in furtherance of this Agreement which obligates Federal appropriations shall be exclusively within the control of the Government. The award of any contract by the Sponsor with a third party for services in furtherance of this Agreement which obligates funds of the Sponsor and does not obligate Federal appropriations shall be exclusively within the control of the Sponsor, but shall be subject to applicable Federal statutes and regulations.

e. The Government and the Sponsor shall each endeavor to assign the necessary resources to provide for the prompt and proper execution of the Study and shall, within the limits of law and regulation, conduct the study with maximum flexibility as directed by the Executive Committee established by Article V herein.

f. The Government will not continue with the Study if it determines that there is no solution in which there is a Federal interest which is not in accord with current policies and budget priorities unless the Sponsor wishes to continue under the terms of this Agreement and the Department of the Army grants an exception. If a study is discontinued, it shall be concluded according to Article XII and all data and information shall be made available to both parties.

g. The Sponsor may wish to conclude the study if it determines that there is no solution in which it has an interest or which is not in accord with its current policies and budget priorities. When such a case exists the study shall be concluded according to Article XII and all data and information shall be made available to both parties.

ARTICLE III - SCOPE OF STUDIES

Appendix A, Scope of Studies and Detailed Costs; Appendix B, Feasibility Phase Study Cost Estimate Summary; and Appendix C, Feasibility Phase Study Cost Sharing are hereby incorporated into this Agreement. The parties to this Agreement shall substantially comply with the Scope of studies in prosecuting work on the Study. The following modifications shall require an amendment to this Agreement.

a. any modification which increases the total Study Cost by more than fifteen (15) percent (see Appendices A and B);

b. any modification in the estimated cost of a Study work item or any obligation for a Study work item, which changes the total cost of that work item by more than fifteen (15) percent (see Appendices A and B);

c. any extension of the Study completion date of more than thirty (30) days; or

d. any reassignment of work items between the Sponsor and the Government (see Appendices A, B and C).

ARTICLE IV - METHOD OF PAYMENT

a. The Government shall endeavor to obtain the appropriation for the amount specified in the Scope of Studies incorporated herein. Subject to the enactment of Federal appropriations and the allotment of funds to the Contracting Officer, the Government shall then fund the Study at least in the amounts specified herein.

b. The Sponsor shall contribute and deliver within thirty (30) days from the signing of this Agreement the cash contribution in the amount specified in the Scope of Studies (Appendix A) incorporated herein and, such funds shall be made available to the Government. The Government shall withdraw and disburse funds made available by the Sponsor subject to the provisions of this Agreement.

c. Funds made available by the Sponsor to the Government and not disbursed by the Government within a Government fiscal year shall be carried over and applied to the cash contribution for the succeeding Government fiscal year; provided, that, upon study termination any excess cash contribution shall be reimbursed to the Sponsor after a final accounting, as specified in Article XII herein.

d. Should either party fail to obtain funds sufficient to make obligations or cash contributions or to incur Study Costs in accordance with the schedule included in the Scope of Studies incorporated herein, it shall at once notify the Executive Committee established under Article V herein.

ARTICLE V - MANAGEMENT AND COORDINATION

a. Overall Study management shall be the responsibility of an Executive Committee consisting of:

The Government	Commonwealth of Massachusetts
Division Engineer Director of Planning	Commissioner, Metropolitan District Commission

b. To provide for consistent and effective communication and prosecution of the items in the Scope of Studies, the Executive Committee shall appoint representatives to serve on a Study Management Team.

c. The Study Management Team will coordinate on all matters relating to prosecution of the Study and compliance with this Agreement, including cost estimates, schedules, prosecution of work elements, financial transactions and recommendations to the Executive Committee for termination, suspension, or amendment of this Agreement.

d. The Study Management Team will prepare quarterly periodic reports on the progress of all work items for the Executive Committee.

ARTICLE VI - DISPUTES

a. The Study Management Team shall endeavor in good faith to negotiate the resolution of conflicts. Any dispute arising under this Agreement which is not disposed of by mutual consent shall be referred to the Executive Committee. The Executive Committee shall resolve such conflicts or determine a mutually agreeable process for reaching a resolution or for termination under Article XII herein.

b. Pending final decision of a dispute hereunder, or pending suspension or termination of this Agreement under Article XII herein, the parties hereto shall proceed diligently with the performance of this Agreement.

ARTICLE VII - MAINTENANCE OF RECORDS

The Government and the Sponsor each shall keep books, records, documents and other evidence pertaining to Study Costs and expenses incurred pursuant to this Agreement to the extent and in such detail as will properly reflect total Study Costs. The

Government and the Sponsor shall maintain such books, records, documents and other evidence for inspection and audit by authorized representatives of the parties to this Agreement. Such material shall remain available for a period of three (3) years following the termination of this Agreement.

ARTICLE VIII - RELATIONSHIP OF PARTIES

a. The parties to this Agreement act in an independent capacity in the performance of their respective functions under this Agreement, and neither party is to be considered the officer, agent, or employee of the other.

b. To prevent conclusive findings, recommendations, etc., from being prematurely and or indiscriminately released against the wishes of either party and to avert misinterpretations and misunderstandings, the following is effected for the period of this Agreement: Prior to approval for public release, except where Federal law otherwise requires disclosure, final Study determinations, including reports, documents, data, findings, conclusions, and recommendations pertaining to the Study, shall not be released without the consent of both parties, nor shall they be represented as presenting the views of either party unless both parties shall indicate explicit agreement.

ARTICLE IX - OFFICIALS NOT TO BENEFIT

No member of or delegate to the Congress, or other elected official, shall be admitted to any share or part of this Agreement, or to any benefit that may arise therefrom.

ARTICLE X - FEDERAL AND STATE LAWS

In acting under its rights and obligations hereunder, the Local Sponsor agrees to comply with all Federal and State laws and regulations, including section 601 of Title VI of the Civil Rights Act of 1964 (Public Law 88-352) and Department of Defense Directive 5500.II issued pursuant thereto and published in Part 300 of Title 32, Code of Federal Regulations, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army."

ARTICLE XI - COVENANT AGAINST CONTINGENT FEES

The Local Sponsor warrants that no person or selling agency has been employed or retained to solicit or secure this Agreement upon agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bona fide established commercial or selling agencies maintained by the Local Sponsor for the purpose of securing business. For breach or violation

of this warranty, the Government shall have the right to annul this Agreement without liability or, in its sole discretion, to add to the Agreement or consideration, or otherwise recover, the full amount of such commission, percentage, brokerage, or contingent fee.

ARTICLE XII - TERMINATION OR SUSPENSION

a. This Agreement shall terminate at the completion of the Study Period: provided, that prior to such time and upon thirty (30) days written notice, either party may terminate or suspend this Agreement without penalty.

b. Within ninety (90) days upon termination of this Agreement the Study Management Team shall prepare a final accounting of the Study Costs, which shall display disbursements by the Government of Federal funds, cash contributions by the Sponsor, and credits for the Negotiated Costs of the Sponsor as defined elsewhere herein. Within thirty (30) days thereafter, the Government shall, subject to the availability of funds, reimburse the Sponsor for the excess, if any, of cash contributions and credits given over fifty (50) percent of the total Study Costs. Within thirty (30) days thereafter, the Sponsor shall provide the Government any cash contributions required so that the total Sponsor share equals fifty (50) percent of the total Study Cost.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement as of the day and year first above written.

THE UNITED STATES OF AMERICA	COMMONWEALTH OF MASSACHUSETTS
BY______________________	BY______________________
Colonel, Corps of Engineers	Mr. M. Ilyas Bhatti
Division Commander	Commissioner Commonwealth of Massachusetts Metropolitan District Commission

Appendix A - Scope of Studies
Appendix B - Study Cost Estimate
Appendix C - Cost Sharing Description

CERTIFICATE OF AUTHORITY

I, _______________, do hereby certify that I am the Attorney General for the Commonwealth of Massachusetts, and that the Commonwealth of Massachusetts is a legally constituted public body with full authority and legal capability to perform the terms of the Agreement between the United States of America and the Commonwealth of Massachusetts in connection with the Nantasket Beach Coastal Flood Protection Feasibility Study and to pay damages, if necessary, in the event of the failure to perform, and that the persons who have executed the Agreement on behalf of the Commonwealth of Massachusetts have acted within their statutory authority.

IN WITNESS WHEREOF, I have made and executed this certificate this ___ day of ________, A.D., 199 .

BY__________________________
Attorney General

APPENDIX A

SCOPE OF STUDIES AND DETAILED COSTS

CORPS OF ENGINEERS WORK
FOR COST SHARED FEASIBILITY PHASE STUDY

NANTASKET BEACH COASTAL FLOOD PROTECTION STUDY
HULL, MASSACHUSETTS

Public Contact and Involvement (Item 1)

Public involvement will be a major work item. Several meetings are planned. In addition to the MDC, close coordination with the Selectmen and other town officials will be maintained. In addition to the time directly spent in meetings, a significant work effort will be needed for planning and coordination.

Element Description	Estimated Cost
* Three informational meetings with the general public. Early in the process, at the middle and end of the study.	$ 1,500
* Quarterly visits with the MDC officials and recorded progress reports of the meetings.	$ 2,000
* Three planning and information gathering visits with town, State and Federal officials.	$ 1,500
* Meeting preparation, planning and evaluation of results. Preparation and dissemination of pertinent information.	$ 3,000
Subtotal	$ 8,000

Hydrology Studies (Item 2)

Technical and engineering information to be compiled by the Hydrologic Engineering and Hydraulics and Water Quality sections will focus on analysis of wind and wave climate, wave overtopping, past flooding, interior drainage and formulation or update of stage

frequency curves for both the shore line and interior areas. Such information will be used in the design of the various plans studied as well as in the economic cost benefit analyses.

*	Analysis of wave, storm surge and wind frequency	$ 5,000
*	Determination of wave overtopping volumes.	$ 4,000
*	Compilation of past flood high watermarks	$ 2,000
*	Review of interior drainage processes and rainfall handling capabilities and requirements.	$ 3,500
*	Development of existing and future stage frequency relationships for both tidal and interior areas.	$ 4,500
*	Preparation of report	$ 4,500
*	Coordination with study team	$ 1,500
	Subtotal	$ 25,000

It is estimated that most of the hydrology work will be performed during the middle 6 months of the project. Much of the work cannot begin until surveying information is complete. A significant amount of the information compiled during the hydrology study must be completed early enough to be used in the economic analysis of the feasibility study.

<u>Surveying and Mapping</u> (Item 3)

Surveying of the backshore of the study area will be necessary to determine elevations of buildings and roadways. The survey of the beach, taken in December of 1992, will be updated and new profiles will be determined. The interior elevations are necessary to provide information for use in the determination of stage frequency curves for flooding. Such elevations are also necessary for the formulation of stage damage curves in conjunction with economic and cost benefit analyses.

*	Backshore of study area.	$ 9,000
*	Update of beach survey and new profiles.	$ 6,000
*	Preparation of map and profiles.	$ 2,500
	Subtotal	$ 17,500

Materials Investigation (Item 4)

Comprehensive survey, with supporting analysis, of potential source samples.	$ 2,500

Design & Cost Estimates (Item 5)

Prepare quantity and cost estimates for alternative plans of improvement. Evaluate alternative plans to arrive at the best plan for the area and maximize benefits. Several different scenarios for design wave and design berms will be prepared. It will be necessary to prepare drawings, draft and layout cross sections, plans and profiles and prepare a report to be used in the feasibility report.

*	Design wave analysis - three scenarios	$ 3,000
*	Design berm - three scenarios	$ 3,000
*	Breakwater design evaluation	$ 1,000
*	Revetment design evaluation	$ 1,000
*	Coordination	$ 2,000
*	Quantity and cost estimates	$ 4,000
*	Drafting	$ 3,000
*	Report writing and review	$ 3,000
	Subtotal	$ 20,000

Economic Studies (Item 6)

Assess and evaluate the economic and social effects of the structural and nonstructural alternate plans. Net benefits will be maximized and the most cost effective plan will be determined through economic analyses. A final report will be submitted to be used in the feasibility report. Several field trips will be necessary.

*	Determine existing shore and backshore flooding damages	$ 10,000
*	Determine future damages	$ 2,500

*	Refine existing without project stage damage functions	$ 10,000
*	Prepare report	$ 7,500
	Subtotal	$ 30,000

<u>Environmental Studies</u> (Item 7)

Perform the necessary field surveys including any necessary transects, cores, specimen collection and identification, and biomass assessment. Determine impacts on the environment anticipated as a result of the construction of the project. Coordinate these efforts with state and Federal agencies such as National Marine Fisheries Service, and Massachusetts Coastal Zone Management. Field trips will be necessary to complete this work. Also prepare and submit an Environmental Assessment in accordance with NEPA, MEPA and applicable state laws and regulations for enclosure in the feasibility report.

*	Benthic survey; specimen collection, enumeration and identification.	$ 5,000
*	Data acquisition	$ 2,000
*	Coordination with federal, state and local agencies.	$ 2,500
*	Report preparation including appropriate NEPA documentation, 404 (b) (1) evaluation and necessary CZM/WQC material.	$ 8,000
*	Local Cooperation	$ 1,000
*	Public review/revision	$ 2,000
	Subtotal	$ 20,500

<u>U.S. Fish and Wildlife Coordination</u> (Item 8)

U.S. Fish and Wildlife Service, in agreement with the Intergovernmental Coordination Act of 1966, will review the project in terms of its environmental acceptability. Includes site visit(s), comment, and correspondence. Two field trips are anticipated, and Planning Aid Letters will be provided.

$ 8,000

Study Management (Item 9)

The overall management and coordination of the entire project includes several elements.

*	Coordination with study team members; team meetings, correspondence, interaction with teams.	$ 5,000
*	Review of work submitted by team members.	$ 3,500
*	Maintenance of financial records and budget; monitoring of expenditures and adherence to work schedules.	$ 3,000
*	Inter/Intra-office correspondence.	$ 1,500
*	Fact Sheet preparation and update	$ 2,000
*	Monthly Progress Reports	$ 3,500
*	Coordinate assignments for study team members.	$ 2,000
*	Establish work and expenditure schedules.	$ 1,500
	Subtotal	$ 22,000

Report Preparation and Corps Review (Item 10)

The compilation of the draft report for review prior to submission entails a variety of tasks including:

*	Writing of text (rough, draft and preliminary).	$ 7,000
*	Preparation of figures and tables.	$ 2,000
*	Compilation and review of appendices.	$ 2,000
*	Editing main report.	$ 2,500
*	Corps review and in house coordination with team members.	$ 4,000
*	Reproduction and mailing.	$ 4,000
*	Project Review Board meeting.	$ 1,000
	Subtotal	$ 22,500

Institutional Analysis (Item 11)

The Office of Counsel will address legal questions that may arise during the study and will assist in preparation of Local Cooperation Agreement in preparation for the construction of the project. Office of Counsel expenses are absorbed into NED overhead costs.

Audit (Item 12)

The Audit Branch will examine, review, and verify the financial accounts, as appropriate.

$ 1,000

Archaeology (Item 13)

*	Background research to determine the historic and prehistoric site potential for the project area.	$ 2,500
*	Site visit to determine architectural significance of structures in the study area.	$ 500
*	Completion of Section 106 (National Preservation Act) coordination with Massachusetts State Historic Preservation Officer.	$ 1,000
*	Input to Environmental Assessment	$ 500
	Subtotal	$ 4,500

Real Estate (Item 15)

The Real Estate Directorate will provide a gross appraisal and planning report for the properties affected, prepare the draft Local Cooperation Agreement and perform other administrative work for the Detailed Project Study.

$ 8,500

Review Contingency (Item 16)

The "Study Cost" includes a Review Contingency equal to the lesser of five (5) percent of the "Study Cost" or $10,000, such amount to be used in the event of work required as a result of Division or Headquarters level review. (Article Ia. in the Agreement.)

$ 10,000

Point of Contact with the Commonwealth of Massachusetts:

Mr. Francis D. Faucher, P.E.
Deputy Director
Engineering and Construction Division
Metropolitan District Commission
20 Somerset Street
Boston, Massachusetts 02108

Point of Contact with the Corps of Engineers will be:

Mr. Charles L. Joyce
CENED-PL-P
U.S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, Massachusetts 02254-9149

APPENDIX B

NANTASKET BEACH COASTAL FLOOD PROTECTION STUDY
FEASIBILITY PHASE STUDY COST ESTIMATE SUMMARY

	COST OF FEDERAL SERVICES
1. Public Contact and Involvement	$ 8,000
2. Hydrology Studies	$ 25,000
3. Survey & Mapping	$ 17,500
4. Materials Investigations	$ 2,500
5. Design and Cost Estimates	$ 20,000
6. Economic Studies	$ 30,000
7. Environmental Studies	$ 20,500
8. USF&WS Coordination	$ 8,000
9. Study Management	$ 22,000
10. Report Preparation	$ 22,500
11. Institutional Analysis	------
12. Audit	$ 1,000
13. Archaeology	$ 4,500
14. Real Estate	$ 8,500
15. Review Contingency	$ 10,000
TOTAL	$200,000

APPENDIX C

NANTASKET BEACH COASTAL FLOOD PROTECTION STUDY

FEASIBILITY PHASE STUDY COST SHARING

The cost of all study efforts are estimated to be $200,000. Since the Federal Government and the non-Federal sponsor are required to share equally in the cost of the feasibility phase of the study it is necessary that the local sponsor, in this case the Commonwealth of Massachusetts, make a cash contribution of $100,000 in order to make each partner's contribution equal to the other. This cost sharing is detailed below.

	Services	Apportionment of costs	
	U.S. Dollars	U.S. Dollars	Percent
Federal	$ 100,000	$100,000	50
Non-Federal	$ 100,000	$ 100,000	50
Total	$200,000	$200,000	100

SECTION III

APPENDICES

APPENDIX A

ENVIRONMENTAL RECONNAISSANCE REPORT

NANTASKET BEACH SHORELINE PROTECTION
HULL, MASSACHUSETTS

ENVIRONMENTAL RECONNAISSANCE REPORT

PREPARED BY:

JAY MACKAY
MARINE ECOLOGIST

U.S ARMY CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS

MARCH 1993

TABLE OF CONTENTS

I. Project History and Description.

In March of 1968, a beach erosion control report for Nantasket Beach was issued in cooperation with the Metropolitan District Commission (MDC). This report recommended that a beach erosion control project be adopted that provides for beach widening by direct placement of suitable sand fill along about 6800 feet of beach fronting the MDC Reservation to a general backshore elevation 17 feet above mean low water which would furnish a recreational and protective beach averaging 190 feet in width behind the mean high water line (See Attachment). The project was subsequently authorized by Congress in December 1970. However, the project was never constructed and was subsequently de-authorized in January 1990.

The 30-31 October 1991 storm caused extensive damage to the rip-rap, sea walls, sidewalks, stairs and ramps along the MDC Reservation at Nantasket Beach. As a result of damages sustained during the storm, the MDC, in a letter dated January 6, 1992, asked the Army Corps of Engineers to reactivate the previously authorized project. Due to the critical nature of this situation it was decided to conduct this Reconnaissance Study under the authority contained in Section 103 of the 1946 Flood Control Act, as amended, that is administered under the Corps Continuing Authorities Program.

II. Alternatives

A number of alternatives, both structural and non-structural, to reduce shore damage and flooding and the vulnerability of this area to flooding are being evaluated and include the following:

<u>ALTERNATIVE/SHORE/FLOOD DAMAGE PREVENTION MEASURES</u>

<u>MODIFYING SHORE DAMAGE/FLOODING</u>	<u>Reduce Vulnerability</u>
Offshore Breakwater	Floodproofing
Revetments	Flood Insurance
Beach Fill	Flood Warning and Evaluation
Groins	

For the purposes of this reconnaissance study, the alternative of beach fill in conjunction with the repair and the replacement of the existing seawall, where necessary, will be assumed to be the preferred project plan. Upon review of the above options, it appears to represent the most acceptable and realistic plan from an engineering, environmental and economical standpoint and therefore will be the most likely to be implemented.

This plan of improvement calls for the placement of clean sand fill material along approximately 6,800 feet of Nantasket Beach fronting the MDC Reservation to a general backshore elevation of 17 feet above mean low water. Starting at the seawall the project would provide a 75 foot wide level beach berm, from here the beach face would then slope seaward with a slope of 1 vertical (V) to 15 horizontal (H) until it intersects the existing ground. This would then provide a protective beach averaging 190 feet in width behind the mean high water line.

The other alternative plans (i.e. offshore breakwaters, revetments and groins) are all considered "hard" solutions to the existing problem and would not likely be viewed as environmentally acceptable alternatives by the Massachusetts Coastal Zone Management Office and other state agencies. Additionally, it has been determined that groin structures would not alleviate present conditions given the fact that sediment transport is in the on-shore / offshore direction as opposed to longshore. The offshore breakwater and revetment plan were also found not to be economically justified.

III. Initial Coordination

The following agencies were contacted during the development of this report (See Attached Correspondence) and will continue to be coordinated with as the study progresses:

U.S. Environmental Protection Agency, Region I
U.S. Fish and Wildlife Service
National Marine Fisheries Service
Massachusetts Coastal Zone Management Office
Massachusetts Division of Marine Fisheries
Massachusetts Department of Environmental Protection
Massachusetts Division of Water Pollution Control
Massachusetts Office of Waterways
Massachusetts Department of Environmental Management
Executive Office of Environmental Affairs
Massachusetts Division of Fisheries and Wildlife

An interagency site visit was conducted on March 4, 1993 to discuss the acceptability of each of the above alternatives and to receive recommendations by interested regulatory agencies.

IV. Environmental Setting

The Nantasket Beach study area lies in the town of Hull, Plymouth County, Massachusetts. The study area is part of an elongated spit extending along a NW-SE axis into Massachusetts Bay running from the southern limit to the northern limit of the MDC Reservation. This beach lies directly on the Atlantic Ocean facing in a northeasterly direction. As a result, swells from ocean storms directly affect this section of coast and is the source of the coastal erosion which is currently being experienced. This area is designated as a public beach according to the Massachusetts Coastal Zone Management Plan (CZM 1977). It is primarily sand and stone cobble which runs the length of the project area and grades seaward producing an intertidal sand flat.

Over the years, this beach system has experienced sand migration away from the shoreline and intertidal areas to the offshore waters, resulting in an undermining of the existing seawall system which runs along the backshore, resulting in the recent total collapse of some sections. No dunes or seagrasses were observed in the project area during the most recent site visit.

V. Environmental Resources

As a result of the lack of sand in the backshore area, the upper beach areas are currently unstable and are mostly underwater during the higher portions of the tidal cycle. These shifting sands provide little, if any, suitable substrate for biota to colonize. No dunes or seagrasses or significant environmental resources were observed within the intertidal area during a cursory site inspection. However, no formal biological sampling program has yet been carried out.

Numerous fragments of surf clams (Spisula solidissima) were observed within the beach area. Initial coordination (CZM, NMFS, various pers. comm.) has revealed that subtidally, a commercially harvestable surf clam population exists in the minus three (-3) to minus ten (-10) meter isopleth. Lobsters (Homarus americanus) are also harvested in the offshore waters.

Environmental concerns as they relate to project implementation would lie with the potential for impact to the commercially harvestable populations of the surf clam and lobsters as outlined above. Prior to project construction and in preparation of the Environmental Assessment, it will be necessary to quantify, through a formal sampling program, the existing benthic and shellfish resources that may inhabit the area. Should sufficient numbers of these individuals be at risk, a relocation plan may be implemented which would temporarily remove existing resources to unaffected areas and then allow repopulation of the stabilized area upon completion of the work.

VI. Threatened and Endangered Species

Initial correspondence with the U.S. Fish and Wildlife Service and National Marine Fisheries Service has indicated that no Federally listed or proposed threatened and endangered species are known to exist within the study area.

VIII. Archaeological and Historic Resources

General

The town of Hull, Massachusetts, originally called Nantasket by the Wampanoag Indians, dates from 1644, when the town was named for a seaport town in Yorkshire, England. It is now known as Nantasket, but it's official name is Hull (Bergan 1972:18).

Known originally as a fishing and agricultural town, in the late 19th Century and the area of the big hotel, Hull entered it's golden era. From the early 1880's to the first world war, these palatial inns and resorts transformed the town into a popular summer resort on the eastern seaboard. During World War I, however, the growth of the automobile had a destructive effect on the hotels, steamboats, and trolleys which served the area. Most of the inns and hotels from this area are now gone (ibid, 18,24,65).

Beginning at about the same time as the rise of the hotel industry, the rise of cottages, primarily as vacation homes, began to predominate the town (Sweetser 1888:76-77). These homes ranging in size from a bungalow to mansion, are the late 19th and 20th Century historic homes which dot the vicinity of the project area.

The Metropolitan District Commission (MDC), formerly known as the Metropolitan Parks Commission, took control of some amusements in town, including Nantasket Beach in 1899 (Bergan 1972:72), and has controlled the popular beach resort since that time.

Impacts

The proposed beach erosion control project for Nantasket Beach could possibly impact prehistoric or underwater archaeological resources, which may be in the vicinity of the project area. There are approximately twenty-seven (27) documented shipwrecks that may be located in the vicinity, as well as, at least eight (8) prehistoric archaeological sites which are known within the Hull area. Floodproofing measures which may be performed on historic homes near the proposed project area, could also impact significant resources. However, this is a preliminary investigation, and if this project proceeds to a further stage in the planning process, then formal comments will be requested from the Massachusetts State Historical Preservation Officer to satisfy Section 106 of the National Historic Preservation Act of 1966, as amended. The Massachusetts State Historic Preservation Officer, in a letter dated November 27, 1992, has concurred with these determinations.

IX. Requirements for Feasibility Level Study

Environmental sampling and testing will be required, including sampling to characterize the benthic and shellfish communities on the beach and in any intertidal and offshore project areas. Other related and necessary environmental efforts would be directed toward interagency coordination, preparation of an Environmental Assessment and a Clean Water Act Section 404(b)1 Evaluation, as well as obtaining a Water Quality Certificate and a Coastal Zone Management Consistency Concurrence. Cummulative impacts analysis will need to assess the frequency and quantity of maintenance renourishment to assure sustainability of this project. The local sponsor will be required to obtain all local permits and Order of Conditions as well as a MEPA Certificate along with any applicable state permits.

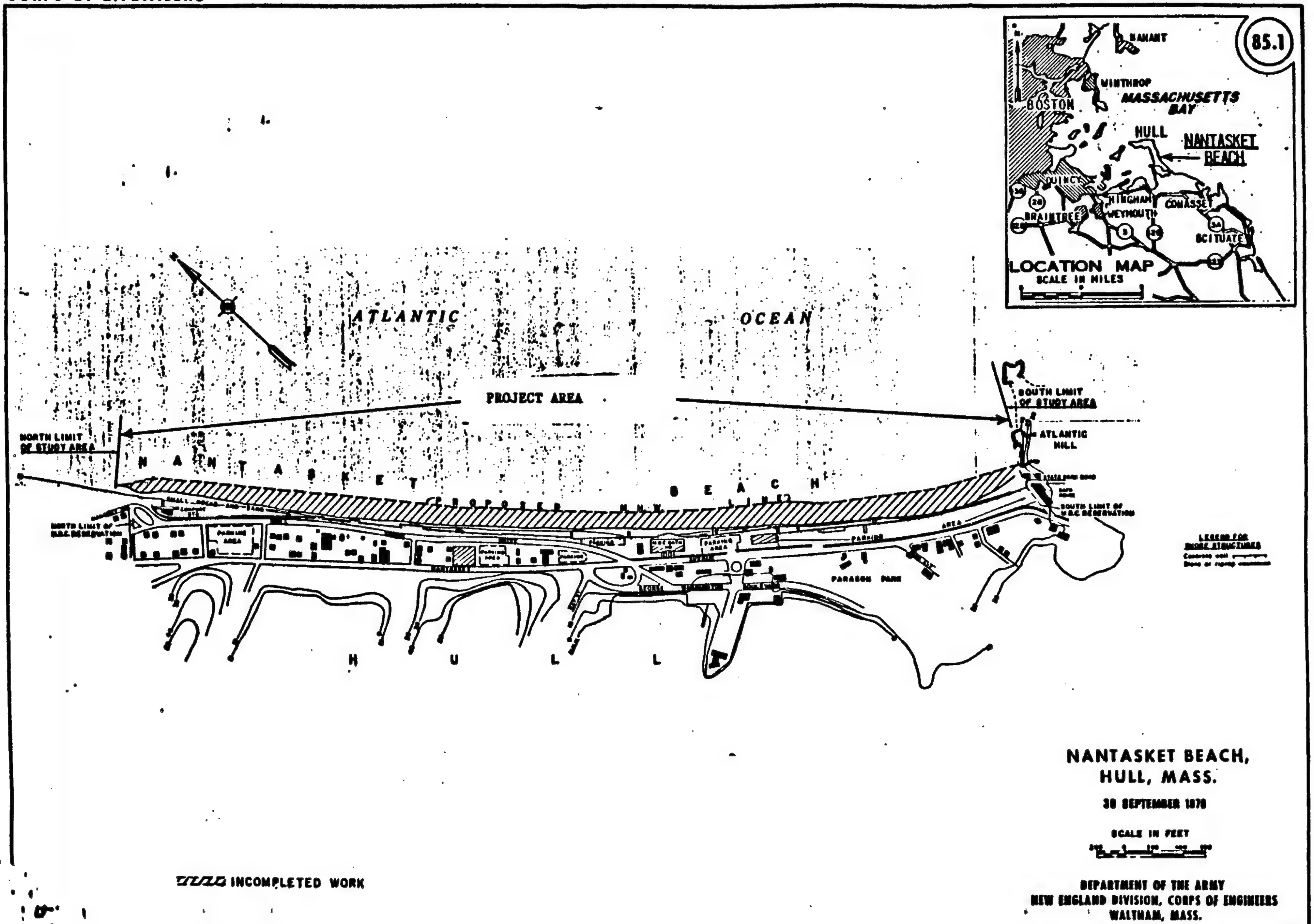
X. References

Bergan, Doctor William M., 1972, Old Nantasket. The Christopher Publishing Company, North Quincy, Massachusetts.

Sweetser, M.F., 1888, King's Handbook of Boston Harbor. Moses King Corporation, Boston, Massachusetts.

Hubbard, William A. USACOE 1987. A Preliminary Reconnaissance Report for the Proposed Backshore Protection Project at Nantasket Beach in Hull, Massachusetts.

USACOE, 1988. Reconnaissance Report. North Nantasket Beach Shore Protection Study, Hull, Massachusetts.


85.1
LOCATION MAP
SCALE IN MILES
NAHANT
WINTHROP
MASSACHUSETTS BAY
BOSTON
HULL
NANTASKET BEACH
QUINCY
HINGHAM
COHASSET
BRAINTREE
WEYMOUTH
SCITUATE
ATLANTIC OCEAN
PROJECT AREA
NORTH LIMIT OF STUDY AREA
SOUTH LIMIT OF STUDY AREA
ATLANTIC HILL
NANTASKET BEACH
PROPOSED MHW LINE
NORTH LIMIT OF M.D.C. RESERVATION
SOUTH LIMIT OF M.D.C. RESERVATION
PARKING AREA
PARAGON PARK
H U L L
INCOMPLETED WORK
NANTASKET BEACH, HULL, MASS.
30 SEPTEMBER 1970
SCALE IN FEET
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PERTINENT CORRESPONDENCE

INCOMING

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254-9149

REPLY TO ATTENTION OF

October 23, 1992

Planning Directorate
Impact Analysis Division

SUBJECT: Section 205 (Local Flood Protection) Reconnaissance Study of Nantasket Beach, Hull, Massachusetts

Ms. Judith McDonough - Executive Director
Massachusetts Historical Commission
80 Boylston Street
Boston, Massachusetts 02116

Dear Ms. McDonough:

The Army Corps of Engineers, New England Division (NED), is preparing a reconnaissance study for proposed Section 205 (Local Flood Protection) activities on Nantasket Beach in Hull, Massachusetts (see location map). The following information is being provided for your preliminary comments.

In March of 1968, a beach erosion control report for Nantasket Beach was issued in cooperation with the Metropolitan District Commission (MDC). This report recommended that a beach erosion control project be adopted that provides for beach widening by direct placement of suitable sandfill along about 6,800 feet of beach fronting the MDC Reservation to a general backshore elevation 17 feet above mean low water, thus furnishing a recreational and protective beach averaging 190 feet in width behind the mean high water line (see attached map). The project was subsequently authorized by Congress in December 1970. However, the project was never constructed and was subsequently de-authorized in January 1990.

The 30-31 October 1991 storm caused extensive damage to the rip rap, sea walls, sidewalks, stairs, and ramps along the MDC Reservation at Nantasket Beach. As a result of the damages sustained during this storm, the MDC, in a letter dated 6 January 1992, asked NED to reactivate the previously authorized project (see attached letter). Due to the critical nature of the situation it has been decided to conduct a Reconnaissance Study under the authority contained in Section 205 of the 1946 Flood Control Act, as amended, that is administered under the Corps Continuing Authorities Program.

The reconnaissance study will consider both structural and nonstructural measures to reduce flooding and the vulnerability of the area to flooding. These include the following:

Flood Reduction Measures	Reduction of Vulnerability
Offshore Breakwater	Floodproofing
Sea Wall Modifications	Flood Warning and Evaluation
Revetments	Flood Insurance
Beach Fill	
Groins	

A review of NED's shipwreck files indicate that approximately twenty-seven (27) documented shipwrecks may be located in the vicinity of the project area. In addition, at least eight (8) prehistoric sites are known within the Hull area. Historic houses which are in the vicinity of the project area could be impacted by possible floodproofing measures.

However, this is a preliminary investigation. If this project proceeds to a further stage in planning, then a detailed flood protection plan will be selected. At that time, the final plan will be evaluated for its effect upon historic properties. We would appreciate your preliminary comments on the proposed project. If this project does proceed to a further planning phase, then formal comments will be requested to satisfy Section 106 of the National Historic Preservation Act of 1966, as amended.

If you have any questions, please feel free to contact Mr. Marc Paiva of the Impact Analysis Division at (617) 647-8796.

Sincerely,

Joseph L. Ignazio
Director of Planning

Enclosures

CONCURRENCE: Judith B. McDonough 11/27/92

JUDITH B. McDONOUGH
EXECUTIVE DIRECTOR
STATE HISTORIC
PRESERVATION OFFICER
MASSACHUSETTS
HISTORICAL COMMISSION

United States Department of the Interior

FISH AND WILDLIFE SERVICE
New England Field Offices
400 Ralph Pill Marketplace
22 Bridge Street, Unit #1
Concord, New Hampshire 03301-4901

March 16, 1993

Joseph Ignazio
Planning Division
Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254-9149

Dear Mr. Ignazio:

This responds to your letter dated February 11, 1993 requesting information on the presence of Federally listed and proposed endangered or threatened species in relation to the proposed Section 205 activities on Nantasket Beach in Hull, Massachusetts.

Based on information currently available to us, no Federally listed or proposed threatened and endangered species under the jurisdiction of the U.S. Fish and Wildlife Service are known to occur in the project area, with the exception of occasional transient endangered bald eagles (Haliaeetus leucocephalus) or peregrine falcons (Falco peregrinus anatum). However, we suggest that you contact Pat Huckery of the Massachusetts Natural Heritage Program, Division of Fisheries and Wildlife at 100 Cambridge St., Boston, MA 02202, (617) 727-9194 for information on state listed species that may be present.

Preparation of a Biological Assessment or further consultation with us under Section 7 of the Endangered Species Act is not required. Should project plans change, or additional information on listed or proposed species becomes available, this determination may be reconsidered. This response relates only to endangered species under our jurisdiction. It does not address other legislation or our responsibilities under the Fish and Wildlife Coordination Act and the Federal Power Act.

Thank you for your cooperation and please contact Susi von Oettingen of this office at (603) 225-1411 if we can be of further assistance.

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Supervisor
New England Field Offices

OUTGOING

February 11, 1993

Planning Division
Impact Analysis Branch

Mr. Gordon E. Beckett, Supervisor
U.S. Department of the Interior
Fish and Wildlife Service
Ecological Services
22 Bridge Street, Ralph Pill Bldg., 4th Floor
Concord, New Hampshire 03301

Dear Mr. Beckett:

The U.S. Army Corps of Engineers, New England Division (NED), is preparing a reconnaissance study for proposed Section 205 (Local Flood Protection) activities on Nantasket Beach in Hull, Massachusetts. The purpose of this letter is to obtain your preliminary comments on this project pursuant to the Fish and Wildlife Coordination Act as amended, and to request a list of threatened and endangered species for the project area, pursuant to Section 7(c) of the Endangered Species Act of 1973 as amended. Enclosed is a location map of the area to aid you in your work.

In March of 1968, a beach erosion control report for Nantasket Beach was issued in cooperation with the Metropolitan District Commission (MDC). This report recommended that a beach erosion control project be adopted that provides for beach widening by direct placement of suitable sand fill along about 6,800 feet of beach fronting the MDC Reservation to a general backshore elevation 17 feet above mean low water, thus furnishing a recreational and protective beach averaging 190 feet in width behind the mean high water line (see attached map). The project was subsequently authorized by Congress in December 1970. However, the project was never constructed and was subsequently de-authorized in January 1990.

The October 30-31, 1991 storm caused extensive damage to the rip-rap, sea walls, sidewalks, stairs and ramps along the MDC Reservation at Nantasket Beach. As a result of the damages sustained during this storm, the MDC, in a letter dated January 6, 1992, asked NED to reactivate the previously authorized project. Due to the critical nature of the situation it has been decided to conduct a Reconnaissance Study under the authority contained in Section 205 of the 1946 Flood Control Act, as amended, that is administered under the Corps continuing Authorities Program.

The reconnaissance study will consider both structural and non-structural measures to reduce flooding and the vulnerability of the area to flooding. These include the following:

Flood Reduction Measures	Reduction of Vulnerability
Offshore Breakwater	Floodproofing
Sea Wall Modifications	Flood Warning Evaluation
Revetments	Flood Insurance
Beach Fill	
Groins	

An interagency site visit will be conducted on Thursday, March 4, 1993 at 11:00 a.m. to review the various alternatives and obtain your comments.

If you require any further information about the proposed project, please contact Mr. Jay Mackay, Marine Ecologist at the Environmental Resources Branch at (617) 647-8142

Sincerely,

Joseph L. Ignazio
Director of Planning

Enclosure

February 11, 1993

Planning Division
Impact Analysis Branch

Mr. Jay Copeland
Mass. Division of Fisheries and Wildlife
100 Cambridge Street
Boston, MA 02202

Dear Mr. Copeland:

The U.S. Army Corps of Engineers, New England Division (NED), is preparing a reconnaissance study for proposed Section 205 (Local Flood Protection) activities on Nantasket Beach in Hull, Massachusetts. The purpose of this letter is to obtain your preliminary comments on this project pursuant to the Fish and Wildlife Coordination Act as amended, and to request a list of State Species of Concern. Enclosed is a location map of the area to aid you in your work.

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If you require any further information about the proposed project please contact Mr. Jay Mackay, Marine Ecologist at the Environmental Resources Branch at (617) 647-8142

Sincerely,

Joseph L. Ignazio
Director of Planning

Enclosure

February 11, 1993

Planning Division
Impact Analysis Branch

Mr. Douglas Beach
NOAA - Fisheries
Habitat Conservation Office
One Blackburn Drive
Gloucester, Massachusetts 01930-2298

Dear Mr. Beach:

The U.S. Army Corps of Engineers, New England Division (NED), is preparing a reconnaissance study for proposed Section 205 (Local Flood Protection) activities on Nantasket Beach in Hull, Massachusetts. The purpose of this letter is to obtain your preliminary comments on this project pursuant to the Fish and Wildlife Coordination Act as amended, and to request a list of threatened and endangered species for the project area, pursuant to Section 7(c) of the Endangered Species Act of 1973 as amended. Enclosed is a location map of the area to aid you in your work.

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If you require any further information about the proposed project please contact Mr. Jay Mackay, Marine Ecologist at the Environmental Resources Branch at (617) 647-8142

Sincerely,

Joseph L. Ignazio
Director of Planning

Enclosure

February 11, 1993

Planning Division
Impact Analysis Branch

SEE "SAME LETTER SENT TO" ATTACHMENT
a

Dear n :

The U.S. Army Corps of Engineers, New England Division (NED), is preparing a reconnaissance study for proposed Section 205 (Local Flood Protection) activities on Nantasket Beach in Hull, Massachusetts. The purpose of this letter is to obtain your preliminary comments on this project which will be utilized in the generation of the report. Enclosed is a location map of the area to aid you in your work.

In March of 1968, a beach erosion control report for Nantasket Beach was issued in cooperation with the Metropolitan District Commission (MDC). This report recommended that a beach erosion control project be adopted that provides for beach widening by direct placement of suitable sand fill along about 6,800 feet of beach fronting the MDC Reservation to a general backshore elevation 17 feet above mean low water, thus furnishing a recreational and protective beach averaging 190 feet in width behind the mean high water line (see attached map). The project was subsequently authorized by Congress in December, 1990. However, the project was never constructed and was subsequently de-authorized in January 1990.

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If you require any further information about the proposed project please contact Mr. Jay Mackay, Marine Ecologist at the Environmental Resources Branch at (617) 647-8142

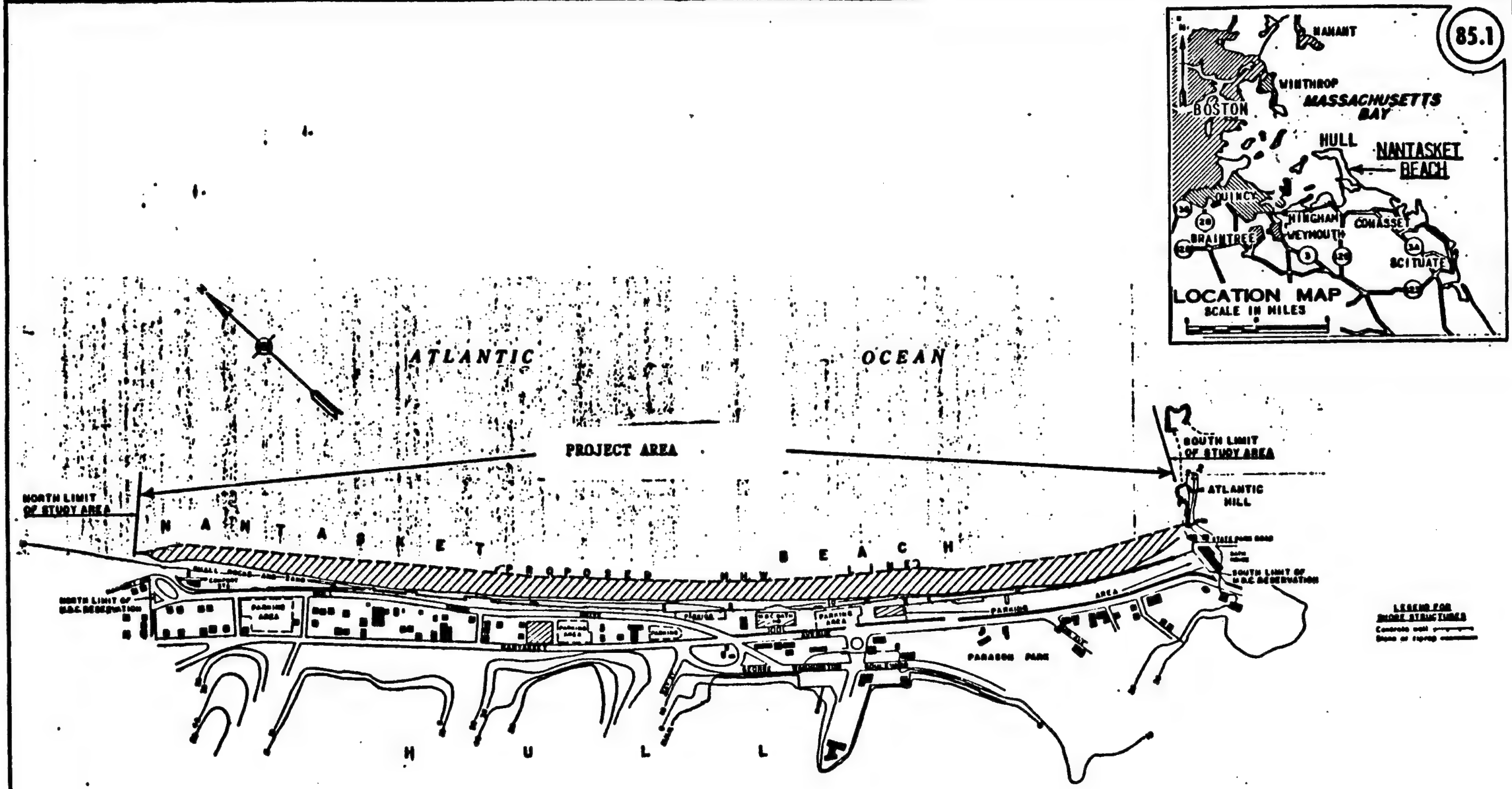
Sincerely,

Joseph L. Ignazio
Director of Planning

Enclosure

CORPS OF ENGINEERS

U.S. ARMY



NANTASKET BEACH,
HULL, MASS.

30 SEPTEMBER 1970

SCALE IN FEET

INCOMPLETED WORK

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

SAME LETTER SENT TO:

Mr. Phillip G. Coates, Director
MA Division of Marine Fisheries
100 Cambridge Street
Boston, Massachusetts 02202

Mr. Brian Donahoe, Director
Department of Environmental Protection
Division of Water Pollution Control
One Winter Street
Boston, Massachusetts 02108

Ms. Judy Perry
Division of Water Pollution Control
One Winter Street
Boston, Massachusetts 02108

Ms. Christy Foote-Smith
Massachusetts Department of Environmental Protection
Division of Wetlands and Waterways Regulation
One Winter Street
Boston, Massachusetts 02108

Mr. Douglas Thompson
Chief, Wetlands Protection Section
U.S. Environmental Protection Agency
JFK Federal Building., Region I
Government Center
Boston, Massachusetts 02203

Mr. Jeffery Benoit
Massachusetts Coastal Zone Management
100 Cambridge Street
Boston, Massachusetts 02202

Ms Jane Meade
Project Review Coordinator
Massachusetts Coastal Zone Management
100 Cambridge Street
Boston, Massachusetts 02202

Mr. Eugene Cavanaugh
Massachusetts Department of Environmental Management
Bureau of Coastal Engineering
100 Cambridge Street
14th Floor
Boston, Massachusetts

Mr. Leslie Lewis ✓
Massachusetts Department of Environmental Management
Bureau of Coastal Engineering
100 Cambridge Street
14th Floor
Boston, Massachusetts

Mr. Daniel Greenbaum, Commissioner
Massachusetts Department of Environmental Protection
One Winter Street
Boston, Massachusetts 02108

Mr. Charles Yelen
Chief of Staff
Executive Office of Environmental Affairs
One Ashburton Place, Room 2101
Boston, Massachusetts 02108

Mr. Douglas Beach
NOAA-Fisheries
Habitat Conservation Office
One Blackburn Drive
Gloucester, Massachusetts 01931-2298

Mr. Gordon E. Beckett
U.S. Department of the Interior
Fish and Wildlife Service
Ecological Services
22 Bridge Street., Ralph Pill Bldg., 4th Floor
Concord, New Hampshire 03301

Mr. Jay Copeland
Massachusetts Division of Fisheries and Wildlife
Natural Heritage and Endangered Species Program
100 Cambridge Street
Boston, Massachusetts 02202

APPENDIX B

PERTINENT CORRESPONDENCE

The Commonwealth of Massachusetts

Metropolitan District Commission

M. Ilyas Bhatti, Commissioner

Office of the Commissioner
20 Somerset Street
Boston, MA 02108
617-727-5114
Fax 617-727-0891

June 8, 1993

Colonel Brink P. Miller
Divsion Engineer
Department of the Army
New England Division, Corps of Engineers
424 Trapelo Rd.
Waltham. Ma. 02254-9149

RE: Nantasket Beach Study

Dear Colonel Miller,

I received your letter of May 18, 1993 with enthusiasm over the prospect of the MDC and the Corps restoring this popular beach and provide much needed reinforcement to the seawalls. Your satisfactory finding for the reconnaissance study is encouraging .and leads to the next step, the feasibility study which is in the best interest of the public.

It is the intent of the MDC to share in the cost of the feasibility study and act as the non-federal sponsor for the project. The shared 50% cost of the feasibility study at an estimated cost of $100,000 to the MDC is acceptable as is the estimated shared 35% construction cost of $1,440,000.

I look forward to further progress with the implementation of the Local Cooperation Agreement in the near future. If there are any questions, please feel free to call me or Mr. Terzian. the Project Manager, at 727-3498.

Sincerely yours,

M. Ilyas Bhatti
Commissioner

cc: N. Baratta
F. Faucher
C. Terzian

Metropolitan Parks Centennial • 1893~1993

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Coleman/kab/7542

February 26, 1993

Planning Directorate
Plan Formulation Division

Mr. Francis D. Faucher, P.E.
Deputy Director
Engineering and Construction Division
Metropolitan District Commission
20 Somerset Street
Boston, Massachusetts 02108

Dear Mr. Faucher:

I am writing in response to your letter of February 1, 1993 regarding our reconnaissance study of the Nantasket Beach area. The study is being conducted under the authority contained in Section 205 of the 1948 Flood Control Act as amended.

The study effort will increase substantially now that we have the economic data you provided in your letter. This information on past and projected future damages to the concrete seawalls and riprap revetment along the MDC Reservation is a very important component of our economic analysis. The damage figures you provided along with those attributable to backshore flooding will be compared to the costs of various protection measures. This comparison will be used to determine if there is sufficient economic justification to support the implementation of a Federal shore protection project at Nantasket Beach. It is anticipated that we will be in a position to make this determination in the Spring.

I trust this information is sufficient for your needs at this time.

Sincerely,

Joseph L. Ignazio
Director of Planning

The Commonwealth of Massachusetts
Metropolitan District Commission
M. Ilyas Bhatti, Commissioner

Technical Services
Division of Engineering
And Construction
20 Somerset Street
Boston, MA 02108
617-727-5264
Fax 617-727-5626

February 1, 1993

Department of the Army
New England Division
Corps of Engineers
424 Trapelo Road
Waltham. Ma 02254

Attn: Mr. Paul Pronovost, Deputy Director
Planning Directorate

RE: Nantasket Beach Erosion. Storms of Oct. 30,1991 and Dec. 11 to13, 1992.

Dear Mr. Pronovost,

This will confirm the discussion between you and Carney Terzian of my staff on Jan. 27, 1993. Mr. Terzian requested a project status report of your Nantasket Beach Project. The MDC is required to respond to the Town of Hull on short and long range plans for the repair/restoration of this beach and seawall. I would appreciate any input you could provide. In addition you asked Mr. Terzian to provide you with economic data for the current damage and projections of future damage based on our recent cost data at Revere Beach.

The damage to the seawalls caused by the storm of Oct. 30, 1991 was discussed in my letter to you of Dec. 31, 1991. The MDC emphasized that the extent of undermining of the seawalls and the erosion of the beach had reached an intolerable level. Therefore, we requested Corps assistance on this problem in accordance with your 1968 report entitled" Beach Erosion Control Report on Cooperative Study of Revere and Nantasket Beaches, Massachusetts"

The coastal storm of Dec. 11 to 13,1992 caused further damage to seawalls at Nantasket beach with the collapse of 400 feet of seawall. A temporary repair to the breached wall has been made. This storm was classified by the Corps of Engineers as being a 10 year event. with stillwater level at El.14.34 (MDC base) and 15 second wave period. The storm continued through six tide cycles which caused damage equivalent to the 1978 storm.

Prior to the storm, the seawall needed to be repaired; after the storm, the seawall further degraded and needs repair due to undermining of the footing; also, many seawall ramps and stairways were damaged by storm waves. This extended storm duration was too much for the poor condition of the seawall to withstand.

The economic data you requested is as follows:

1. ESTIMATE FOR SEAWALL $/LF---Cost data for similar construction at Revere Beach South Bastion Wall based on April 1990 prices is presented. The average of all bids will be used in addition to demolition, excavation and backfill cost; also, an added new 10 ft steel sheet pile cutoff cost.

Average cost South BastionWall		=$136,375
Average cost Demolition SBW		=$ 33,825
Length = 118 ft	Sub total	=$170,200

Cost/ foot of wall= $170,200/118 LF		=$ 1,442/lf
Sheet pile cutoff= 10'+1.5'= 11.5' x 37#/ft x $1/#		=$ 425/lf
Excavation= 5 cy/lf x 10$/cy		=$ 50/lf
Compacted Gravel Backfill= 7 cy/lf x 20$/cy		=$ 140/lf
	Sub total	=$ 2057/lf

Update cost to 1993
ENR 1/11/93=5973, ENR 4/01/90=5341, ratio=5973/5341=x1.12
Current Cost/ft = $2057 x 1.12 =$ 2304/ft

Current Estimate for Nantasket Seawall SAY =$2300/ft

Total length of seawall including ramps& stairs =5600 ft

Current cost for seawall replacement=5600x$2300=$12,880,000

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2. TABLE OF COST FACTORS FOR 1992 TO 1997

DATE	EST. ENR-CCI	RATIO	COST $/LF	REPLACMENT COST
OCT 1991	5800			
DEC 1992	5973	1.03	2300	$12,880,000
1993	6212	1.04	2392	$13,395,000
1994	6460	1.08	2484	$13,910,000
1995	6719	1.12	2576	$14,425,000
1996	6987	1.17	2691	$15,070,000
1997	7227	1.21	2783	$15,585,000

3. DAMAGE IN 5 YEARS DUE TO SUBSEQUENT STORMS--Assume a low return period storm recurs annually for 5 years and the seawall is destroyed and repaired in equal increments in 5 years as follows:

DATE	DAMAGE LENGTH FT		COST $/FT	COST /YEAR
1993	1120		2392	$2,679,000
1994	1120		2484	$2,782,000
1995	1120		2576	$2,885,000
1996	1120		2691	$3,014,000
1997	1120		2783	$3,117,000
TOTAL REPLACE	5600	AVG. COST	2585	$14,477,000

I hope the economic data presented is sufficient for your use; if more is needed, please feel free to call me or Mr. Terzian at 617-727-7220 for further information.

Sincerely yours,

Francis D. Faucher, PE
Deputy Director
Engineering & Construction Div.

cc: N. Baratta
C. Terzian
H. Higgott

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254-9149

REPLY TO ATTENTION OF

February 11, 1993

Planning Division
Impact Analysis Branch

Mr. Jay Copeland
Mass. Division of Fisheries and Wildlife
100 Cambridge Street
Boston, MA 02202

Dear Mr. Copeland:

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Revetments	Flood Insurance
Beach Fill	
Groins	

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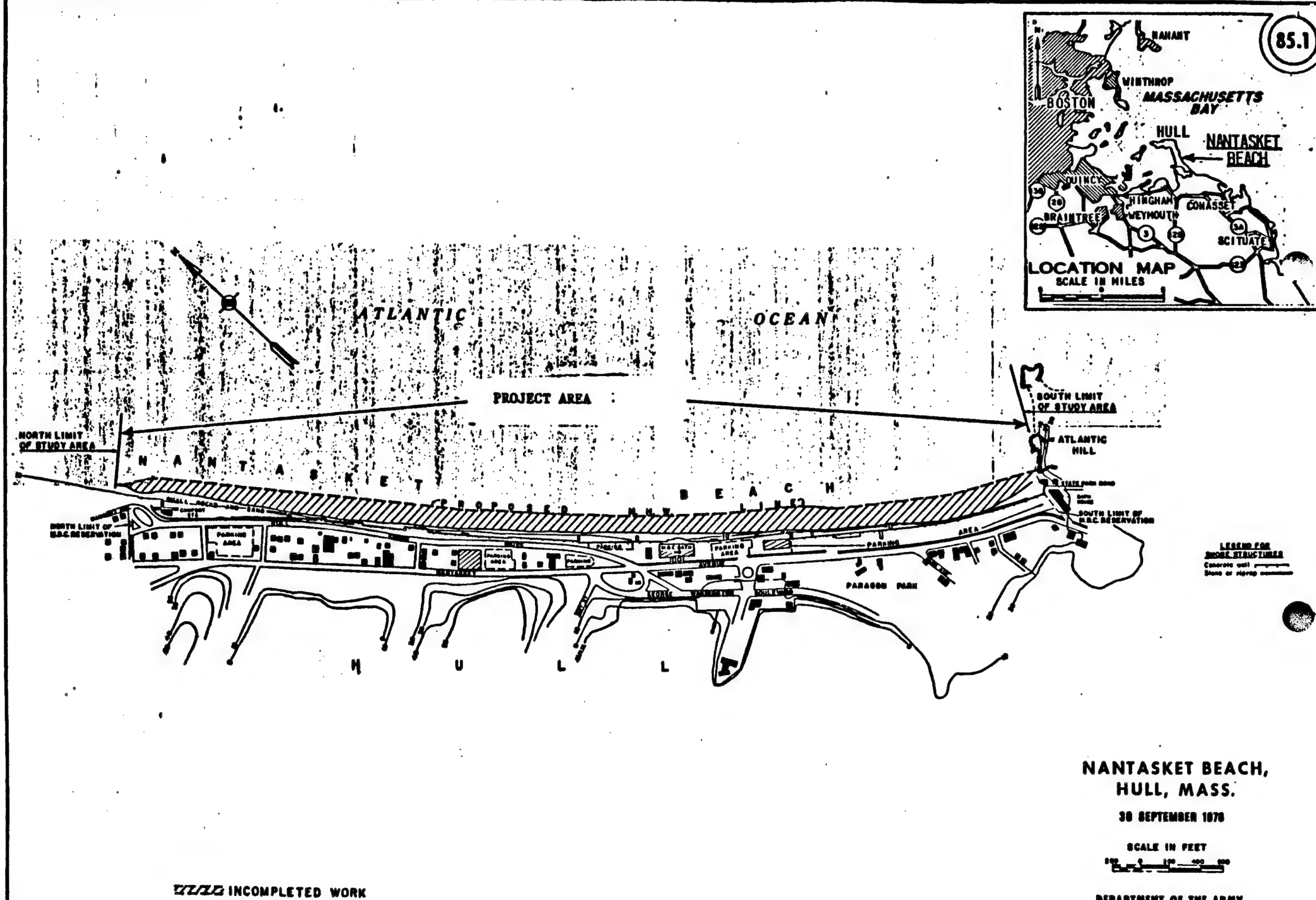
Sincerely,

Joseph L. Ignazio
Director of Planning

Enclosure

CORPS OF ENGINEERS

U.S. ARMY



NANTASKET BEACH,
HULL, MASS.

30 SEPTEMBER 1970

SCALE IN FEET

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

SAME LETTER SENT TO:

Mr. Phillip G. Coates, Director
MA Division of Marine Fisheries
100 Cambridge Street
Boston, Massachusetts 02202

Mr. Brian Donahoe, Director
Department of Environmental Protection
Division of Water Pollution Control
One Winter Street
Boston, Massachusetts 02108

Ms. Judy Perry
Division of Water Pollution Control
One Winter Street
Boston, Massachusetts 02108

Ms. Christy Foote-Smith
Massachusetts Department of Environmental Protection
Division of Wetlands and Waterways Regulation
One Winter Street
Boston, Massachusetts 02108

Mr. Douglas Thompson
Chief, Wetlands Protection Section
U.S. Environmental Protection Agency
JFK Federal Building., Region I
Government Center
Boston, Massachusetts 02203

Mr. Jeffery Benoit
Massachusetts Coastal Zone Management
100 Cambridge Street
Boston, Massachusetts 02202

Ms Jane Meade
Project Review Coordinator
Massachusetts Coastal Zone Management
100 Cambridge Street
Boston, Massachusetts 02202

Mr. Eugene Cavanaugh
Massachusetts Department of Environmental Management
Bureau of Coastal Engineering
100 Cambridge Street
14th Floor
Boston, Massachusetts

Mr. Leslie Lewis ✓
Massachusetts Department of Environmental Management
Bureau of Coastal Engineering
100 Cambridge Street
14th Floor
Boston, Massachusetts

Mr. Daniel Greenbaum, Commissioner
Massachusetts Department of Environmental Protection
One Winter Street
Boston, Massachusetts 02108

Mr. Charles Yelen
Chief of Staff
Executive Office of Environmental Affairs
One Ashburton Place, Room 2101
Boston, Massachusetts 02108

Mr. Douglas Beach
NOAA-Fisheries
Habitat Conservation Office
One Blackburn Drive
Gloucester, Massachusetts 01931-2298

Mr. Gordon E. Beckett
U.S. Department of the Interior
Fish and Wildlife Service
Ecological Services
22 Bridge Street., Ralph Pill Bldg., 4th Floor
Concord, New Hampshire 03301

Mr. Jay Copeland
Massachusetts Division of Fisheries and Wildlife
Natural Heritage and Endangered Species Program
100 Cambridge Street
Boston, Massachusetts 02202

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254-9149

RECEIVED
OCT 28 1992
MASS. HIST. COMM.

REPLY TO
ATTENTION OF

October 23, 1992

Planning Directorate
Impact Analysis Division

SUBJECT: Section 205 (Local Flood Protection) Reconnaissance Study of Nantasket Beach, Hull, Massachusetts

Ms. Judith McDonough - Executive Director
Massachusetts Historical Commission
80 Boylston Street
Boston, Massachusetts 02116

Dear Ms. McDonough:

The Army Corps of Engineers, New England Division (NED), is preparing a reconnaissance study for proposed Section 205 (Local Flood Protection) activities on Nantasket Beach in Hull, Massachusetts (see location map). The following information is being provided for your preliminary comments.

In March of 1968, a beach erosion control report for Nantasket Beach was issued in cooperation with the Metropolitan District Commission (MDC). This report recommended that a beach erosion control project be adopted that provides for beach widening by direct placement of suitable sandfill along about 6,800 feet of beach fronting the MDC Reservation to a general backshore elevation 17 feet above mean low water, thus furnishing a recreational and protective beach averaging 190 feet in width behind the mean high water line (see attached map). The project was subsequently authorized by Congress in December 1970. However, the project was never constructed and was subsequently de-authorized in January 1990.

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The reconnaissance study will consider both structural and nonstructural measures to reduce flooding and the vulnerability of the area to flooding. These include the following:

<u>Flood Reduction Measures</u>	<u>Reduction of Vulnerability</u>
Offshore Breakwater	Floodproofing
Sea Wall Modifications	Flood Warning and Evaluation
Revetments	Flood Insurance
Beach Fill	
Groins	

A review of NED's shipwreck files indicate that approximately twenty-seven (27) documented shipwrecks may be located in the vicinity of the project area. In addition, at least eight (8) prehistoric sites are known within the Hull area. Historic houses which are in the vicinity of the project area could be impacted by possible floodproofing measures.

However, this is a preliminary investigation. If this project proceeds to a further stage in planning, then a detailed flood protection plan will be selected. At that time, the final plan will be evaluated for its effect upon historic properties. We would appreciate your preliminary comments on the proposed project. If this project does proceed to a further planning phase, then formal comments will be requested to satisfy Section 106 of the National Historic Preservation Act of 1966, as amended.

If you have any questions, please feel free to contact Mr. Marc Paiva of the Impact Analysis Division at (617) 647-8796.

Sincerely,

Joseph L. Ignazio
Director of Planning

Enclosures

CONCURRENCE: Judith B. McDonough 11/27/92

JUDITH B. Mc DONOUGH
EXECUTIVE DIRECTOR
STATE HISTORIC
PRESERVATION OFFICER
MASSACHUSETTS
HISTORICAL COMMISSION

PRONOVOST

Pronovost/kab/7511

March 24, 1992

Planning Directorate

Mr. Francis D. Faucher, P.E.
Acting Director
Commonwealth of Massachusetts
Metropolitan District Commission
Engineering and Construction Division
20 Somerset Street
Boston, Massachusetts 02108

Dear Mr. Faucher:

I am writing in response to your letter of January 6, 1992 and the follow-up meeting held with Messrs. Terzian and Higgott of your staff on March 13, 1992 here in Waltham.

As discussed at the March 13th meeting, the New England Division is preparing to initiate a reconnaissance study of the Nantasket Beach area under Section 205 of the 1948 Flood Control Act as amended. The reconnaissance study will be undertaken at 100% federal cost and take about 12 months to complete. Throughout the study, close coordination will be maintained with you and local officials.

I trust this action meets your needs and I look forward to working with you.

Sincerely,

Joseph L. Ignazio
Director of Planning

cc:
Mr. Pronovost
Planning Dir. Files/114N
MR SMITH

The Commonwealth of Massachusetts
Metropolitan District Commission
M. Ilyas Bhatti, Commissioner

20 Somerset Street
Boston, MA 02108
617-727-5264
617-727-5265

Engineering & Construction Division

The Metropolitan Network of Services

Parks
Beaches
Community Boating
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Recreational Facilities
Public Concerts
Trailside Museum
Boston Harbor Islands
Metropolitan Police
Flood Control
Watershed Management
Pure Water Supply
Quabbin, Wachusett and Sudbury Reservoirs
Franklin Park and Stone Memorial Zoos
Parkway, Boulevard and Bridge System
Charles, Mystic and Neponset Rivers
Beaver Brook, Blue Hills, Elm Bank, Breakheart, Middlesex Fells, and Stony Brook Reservations

January 6, 1992

Department of the Army
New England Division
Corps of Engineers
424 Trapelo Road
Waltham, MA 02254

Attn: Mr. Paul Pronovost, Deputy Director
Planning Directorate

Re: Nantasket Beach Erosion, Storm of October 30, 1991

Dear Mr. Pronovost:

This correspondence confirms a discussion, on December 9, 1991, between you and Carney Terzian and Henry Higgott of my staff. This meeting was held in the Hull Town Hall with local officials and concerned beach erosion at Nantasket Beach.

The meeting on December 9th focused on the damage to Nantasket Beach as a result of the October 30th storm. This storm had 55 to 70 mph winds from the northeast which drove offshore waves to 20 feet thus creating an onshore surge of 4 feet atop a high tide of elevation 110.2.

This storm caused damage to 1200 feet of riprap, 370 feet of seawall, sidewalks, stairs, and ramps. Sand lost from the beach, estimated at 250,000 c.y. has exposed footings of seawalls over most of its 6800 foot length. The MDC has emphasized that the extent of undermining of the seawalls and erosion of the beach has reached a hazardous and intolerable level. The Corps of Engineers addressed shore protection of Nantasket Beach in a 1968 report entitled "Beach Erosion Control Report on Cooperative Study of Revere and Nantasket Beaches, Massachusetts."

Therefore, we are requesting that the Corps reactivate this project and offer this agency engineering support as well as financial assistance in the resolution of this problem. This will prevent destruction of shore protection, the beach, and the roadway link to Hull. In the 1968 report the Corps of Engineers recommends placing sand to elevation 17.0 above mean low water which is an estimated quantity of 700,000 c.y. to prevent destruction of the seawall. Our engineers have estimated that the structural repairs and resanding necessary at Nantasket Beach will cost approximately $9.4 million.

I am requesting that we set up a meeting to discuss this project further. The MDC is especially interested in entertaining the possibility of a joint venture between the MDC and the ACOE to stabilize and resand this important public asset as recognized in your 1968 report.

Please contact me at 727-5264 to arrange a mutually convenient time for a meeting. Thank you for your assistance.

Sincerely,

Francis D. Faucher, P.E.
Acting Director

FDF/RP

cc: Noel Baratta
Carney Terzian
Henry Higgott
Robin Pfetsch

APPENDIX C

ECONOMIC ASSESSMENT

WATER RESOURCE IMPROVEMENT STUDY

NANTASKET BEACH

HULL, MASSACHUSETTS

HURRICANE, STORM AND FLOOD DAMAGE REDUCTION PROJECT RECONNAISSANCE REPORT

APPENDIX C

ECONOMIC ASSESSMENT

PREPARED BY:
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
NEW ENGLAND DIVISION

MAY 1993

ECONOMIC ASSESSMENT
TABLE OF CONTENTS

INTRODUCTION

The purpose of this report is to provide an economic analysis of potential inundation reduction and hurricane and storm damage reduction benefits in the Nantasket Beach area of Hull, Massachusetts. Plans that reduce flooding damages and hurricane and storm damages are evaluated. For each plan annual benefits are divided by annual costs to determine a benefit cost ratio. This ratio must be equal to or greater than one for federal participation in water resource improvement projects.

METHODOLOGY

Benefits and costs are made comparable by conversion to average annual equivalents. An interest rate of 8-1/4% as specified in the Federal Register is to be used by Federal agencies in the formulation and evaluation of water and land resource plans for the period 1 October 1992 to 30 September 1993. All costs and benefits are stated at the 1993 price level. The project economic life is considered to be 50 years. The analysis of costs and benefits follows standard U.S. Army Corps of Engineers procedures.

STUDY AREA

Nantasket Beach is located in the Town of Hull, Plymouth County, Massachusetts, about four miles southeast of the main entrance to Boston Harbor and 12 miles southeast of the City of Boston. The study area includes the southern end of the beach. The 1990 population was 10,466. Hull is a suburban residential resort town with the majority of its civilian employment and payroll concentrated in service and retail trade.

HURRICANE AND STORM DAMAGE

Damage to Seawall

Currently the Metropolitan District Commission (MDC) maintains a seawall and other ancillary facilities in back of the beach. The wall extends for 6800 feet and was constructed in stages starting in 1915 and extending through 1938. Sand eroded from the beach has exposed the footings of the seawall over most of its length and in some areas the footings are undermined. The MDC estimates that under existing conditions they would need to expend $2,679,000 annually to repair the seawall. They would be required to replace 1120 feet of wall annually. This represents one-fifth of the wall and a total wall replacement of 5600 feet may be necessary if no protection measures are taken over the next five years.

Recently the storm of October 31, 1991 caused extensive damage to the seawall including some stairways and ramps. Due to their deteriorated condition the MDC has closed the damaged ramps and stairways. Thus the public's access to or egress from the beach which is subject to high wave action is limited. It is estimated that 6 feet of sand was lost during this storm exposing footings and rendering the wall susceptible to future damage. The MDC has estimated that repairs following the storm would cost approximately $1,100,000. In the coastal storm of December 11 to 13, 1992, the seawalls were further damaged and caused the collapse of 400 feet of seawall.

Flooding Damage

There are three hydrologic zones in back of Nantasket Beach. Zone 1 is located in the northern project area between Whitehead Street and the north end of Bay Street. There are five commercial structures located in this zone in the 100 Year floodplain. Zone 2 is located between the northern end of Bay Street and Wharf Avenue. There are 26 commercial structures and 5 residential structures in the 100 year floodplain. Zone 3 is located in the southern most section of the project area between Wharf Avenue and the south end of the seawall at Atherton Road. There are 24 commercial buildings and 21 residential buildings in the 100 year floodplain.

Recurring damages or those damages estimated to occur for a particular frequency storm are shown below for the 10 and 100 year storms.

Zone	10 Year	100 Year
1	$100	$12,000
2	$76,700	$237,800
3	$150,900	$277,500
Total	$227,700	$527,300

Expected annual damages by zone are

Zone 1	$ 400
Zone 2	$35,200
Zone 3	$70,600

for a total of $106,200.

PROJECT BENEFIT

Project benefits result from the reduction in damages to the seawall and the reduction in flooding damages to the backshore that could be attributed to the project. Damage reduction is the difference between damages with and without the project in place.

Seawall Damages

With the project seawall damages are expected to be minor. Thus the project benefit for seawall damage reduction is estimated at $2,679,000.

Flooding Damages

Project benefit is the reduction in flooding damage provided by the project. Damages are developed both without and with the project in place. The differences in these magnitudes by zone is

Zone	Without Project Damages	With Project Damages	Benefit
1	$400	0	$400
2	$35,200	$11,000	$24,200
3	$70,600	$37,000	$33,600
Total	$106,200	$48,000	$58,200

Benefit Summary

Project benefits are summarized below

Type	
Seawall Damage Reduction	$2,679,000
Flood Damage Reduction	58,200
Total	$2,737,200

Recreation

The implacement of sand as part of hurricance and storm damage reduction project will provide incidental recreation benefit. Currently there is very little dry beach area at high tide. Given that the regional demand for dry beach space exceeds supply in this area, provision of dry beach space will lead to recreation benefit for users of Nantasket Beach. This recreation benefit will be evaluated in the Feasibility Phase of the study.

Sensitivity Analysis

Project benefits consist mainly of reduced maintenance and repairs to the sea wall. If the extent of repairs were reduced by 50 % benefits would be

Benefit	
Reduced Damage to Seawall	$1,339,500
Reduced Flooding	$ 58,200
Total	$1,397,700.

APPENDIX D

HYDROLOGY AND HYDRAULICS

APPENDIX D

HYDROLOGY AND HYDRAULICS
COASTAL FLOOD REDUCTION STUDY
NANTASKET BEACH, HULL, MASSACHUSETTS

PREPARED BY
HYDRAULICS AND WATER QUALITY
AND
HYDROLOGIC ENGINEERING BRANCHES
WATER CONTROL DIVISION
ENGINEERING DIRECTORATE

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASSACHUSETTS 02254-9149

MAY 1993

APPENDIX D

HYDROLOGY AND HYDRAULICS
COASTAL FLOOD REDUCTION STUDY
NANTASKET BEACH, HULL, MASSACHUSETTS

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

APPENDIX D

HYDROLOGY AND HYDRAULICS
COASTAL FLOOD REDUCTION STUDY
NANTASKET BEACH, HULL, MASSACHUSETTS

1. PURPOSE

This reconnaissance report presents the results of studies concerning coastal flooding conditions of Nantasket Beach, Hull, Massachusetts. The study was performed under authority contained in Section 103 of the 1948 Flood Control Act. Flood conditions in the Nantasket Beach area are caused mainly by wave overtopping and to a lesser extent due to rainfall. After damage caused by the 31 October 1991 storm, reconnaissance studies were conducted to assess flooding problems and determine possible flood control alternatives. Included are a general description and sections concerning tidal, and interior hydrologic analysis.

2. DESCRIPTION

Nantasket Beach is a recreation and commercial area located in the southern section of a peninsula in the town of Hull, Plymouth County, about 12 miles southeast of the city of Boston. The study includes analysis of wave runup and overtopping the beach seawall and flood assessment of interior areas. The relatively flat interior area drains into Hingham Bay. A general plan of the area is shown on plate D-1.

3. CLIMATOLOGY

a. General. Nantasket Beach has a semi-humid variable climate typical of New England. The peninsula lies in the path of the prevailing "westerlies." Due to direct coastal exposure, it frequently experiences periods of intense precipitation, produced by local thunderstorms and large weather systems of tropical or extra-tropical origin such as "northeasters", producing high tides and waves common to the New England area. The area has an annual mean temperature of 50.5 degrees Fahrenheit; mean monthly temperatures vary between 72.7 in July to 28.8 in January. Monthly climatological information developed at Boston but considered applicable for Nantasket Beach is shown in table D-1.

b. Precipitation. Mean annual precipitation at Boston Logan Airport has been recorded to be 42.98 inches. Short duration intense rainfall often accompanies fast moving frontal systems,

TABLE D-1

BOSTON, MASSACHUSETTS MONTHLY CLIMATOLOGIC DATA

Month	Precipitation (1962-1991) Mean	Temperature (1962-1991) Mean	Max	Min	Prevailing Wind (1962-1991) Mean (MPH)	Direction
		(Degrees Fahrenheit)				
January	3.69	28.8	63	-12	13.9	NW
February	3.45	29.4	70	- 4	13.8	WNW
March	3.95	37.2	81	6	13.8	NW
April	3.80	47.2	94	16	13.2	WNW
May	3.42	57.9	95	34	12.2	SW
June	3.22	67.1	100	45	11.5	SW
July	3.29	72.7	102	50	11.0	SW
August	3.77	70.9	102	47	10.8	SW
September	3.29	64.1	100	38	11.3	SW
October	3.38	54.1	90	28	12.0	SW
November	3.99	43.7	78	15	12.9	SW
December	3.79	32.8	73	-7	13.6	WNW
Annual	42.98	50.5	102	-12	12.5	SW

thunderstorms, and coastal storms. Precipitation is distributed quite uniformly throughout the year averaging about 3.5 inches per month. Peak storm rainfall frequency-duration data as reported in U.S. Weather Bureau Technical Paper 40 is summarized in table D-2. Also, the average annual snowfall at Boston is 43 inches occurring primarily from December through March.

TABLE D-2

RAINFALL FREQUENCY DURATION
USWB TECHNICAL PAPER 40
BOSTON MASSACHUSETTS
(Inches)

		Duration in Hours				
Annual Frequency		1	2	6	12	24
50%	(2-year)	1.1	1.5	2.1	2.6	3.1
20%	(5-year)	1.5	2.0	2.8	3.4	4.0
10%	(10-Year)	1.8	2.3	3.3	3.9	4.6
2%	(50-Year)	2.4	3.1	4.3	5.1	6.0
1%	(100-Year)	2.6	3.3	4.7	5.8	6.8

4. TIDAL HYDROLOGY

a. Astronomical Tides. In the study area (figure D-1), tides are semidiurnal, with two high and two low waters occurring during each lunar day (approximately 24 hours, 50 minutes). The resulting tide range is constantly varying in response to the relative positions of the earth, moon, and sun, with the moon having the primary tide producing effect. Maximum tide ranges occur when the orbital cycles of these bodies are in phase. A complete sequence of tide ranges is repeated over an approximate interval of 19 years, known as a tidal epoch.

(1) Boston. At the National Ocean Survey (NOS) tide gage in Boston, Massachusetts (the one nearest to the study area), the mean range of tide and mean spring range of tide are 9.5 and 11.0 feet, respectively. However, maximum and minimum predicted astronomic tide ranges at Boston have been estimated at about 14.7 and 5.0 feet, respectively,

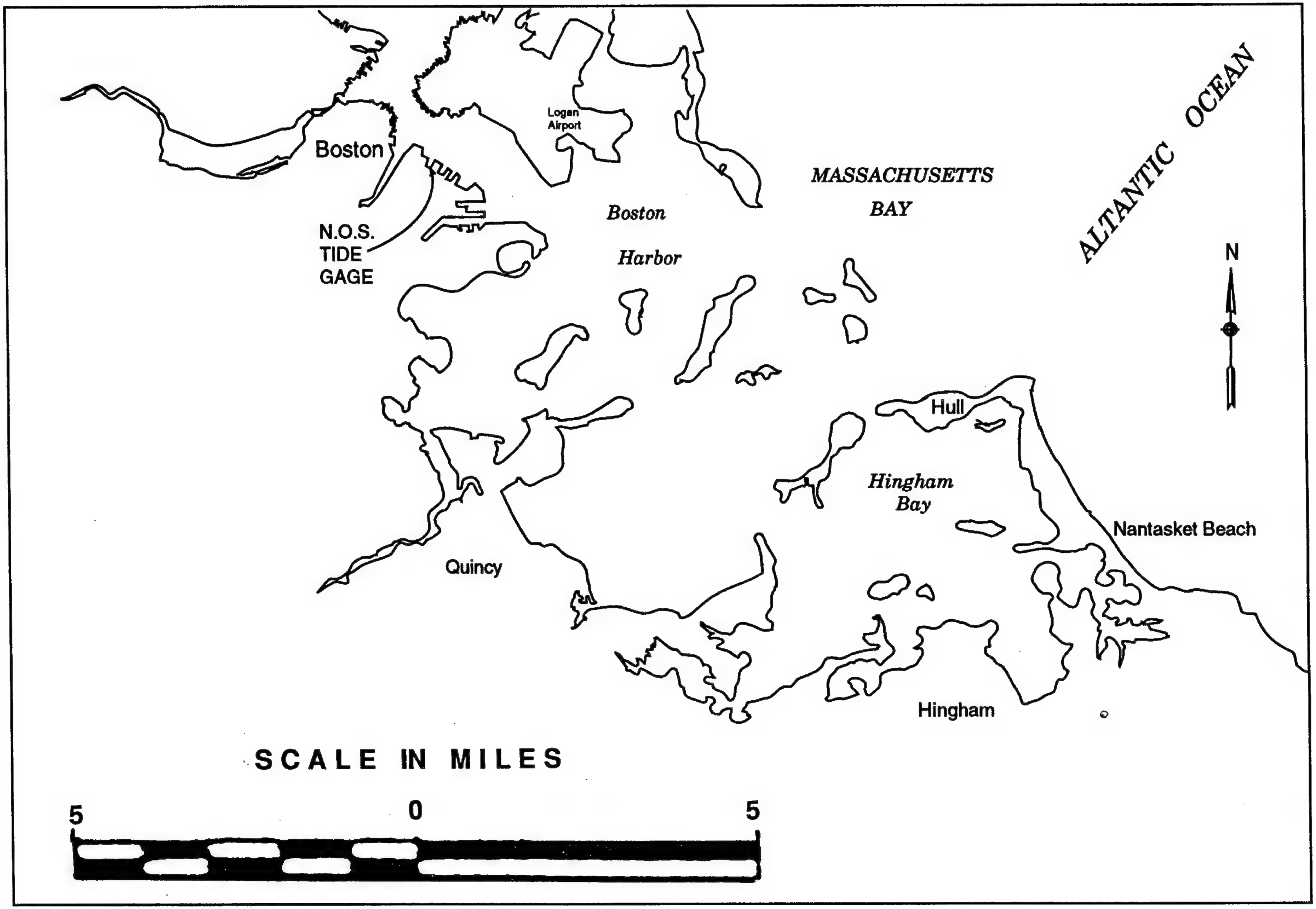


Figure D-1. Study area vicinity

using the Coastal Engineering Research Center (CERC) report, entitled "Tides and Tidal Datums in the United States," SR No. 7, 1981. The frequency of astronomic tidal fall (the difference between consecutive high and low tides), as determined by CERC, is presented in figure D-2. The variability of astronomical tide ranges is a very significant factor in tidal flooding potentials throughout the area under study, and is further explained in section 4d.

Because of continual variation in water level due to tides, several reference planes, called tidal datums, have been defined to serve as a reference points for measuring elevations of both land and water. Tidal datum information for Boston is presented on figure D-3 and table D-3. The data were compiled from currently available NOS tidal benchmark information for Boston, along with the previously mentioned CERC report. The epoch for which the National Ocean Survey has published tidal datum information for Boston is 1960-78. A phenomenon that has been observed through tide gaging and tidal benchmark measurements is that sea level is apparently rising with respect to land along most of the U.S.A. Coast. At the Boston National Ocean Survey tide gage, the rise has been observed to be slightly less than 0.1 foot per decade. Sea level determination is generally revised at intervals of about 25 years to account for the changing sea level phenomenon.

(2) Study Area. In the Nantasket Beach study area, tides are nearly identical to those observed at Boston.

b. Storm Types. Two distinct types of storms, distinguished primarily by their place of origin as being extratropical and tropical cyclones, influence coastal process in New England. These storms can produce above normal water levels and waves, and must be recognized in studying New England coastal problems.

(1) Extratropical Cyclones. These are the most frequently occurring variety of cyclones in New England. Low pressure centers frequently form or intensify along the boundary between a cold, dry continental air mass and a warm, moist marine air mass just off the coast of Georgia or the Carolinas, and move northeastward more or less parallel to the coast. These storms derive their energy from the temperature contrast between cold and warm air masses. The organized circulation pattern associated with this type of storm may extend for 1,000 to 1,500 miles from the storm center. The wind field in an extratropical cyclone is generally asymmetric with the highest winds in the northeastern quadrant. When the storm center passes parallel and

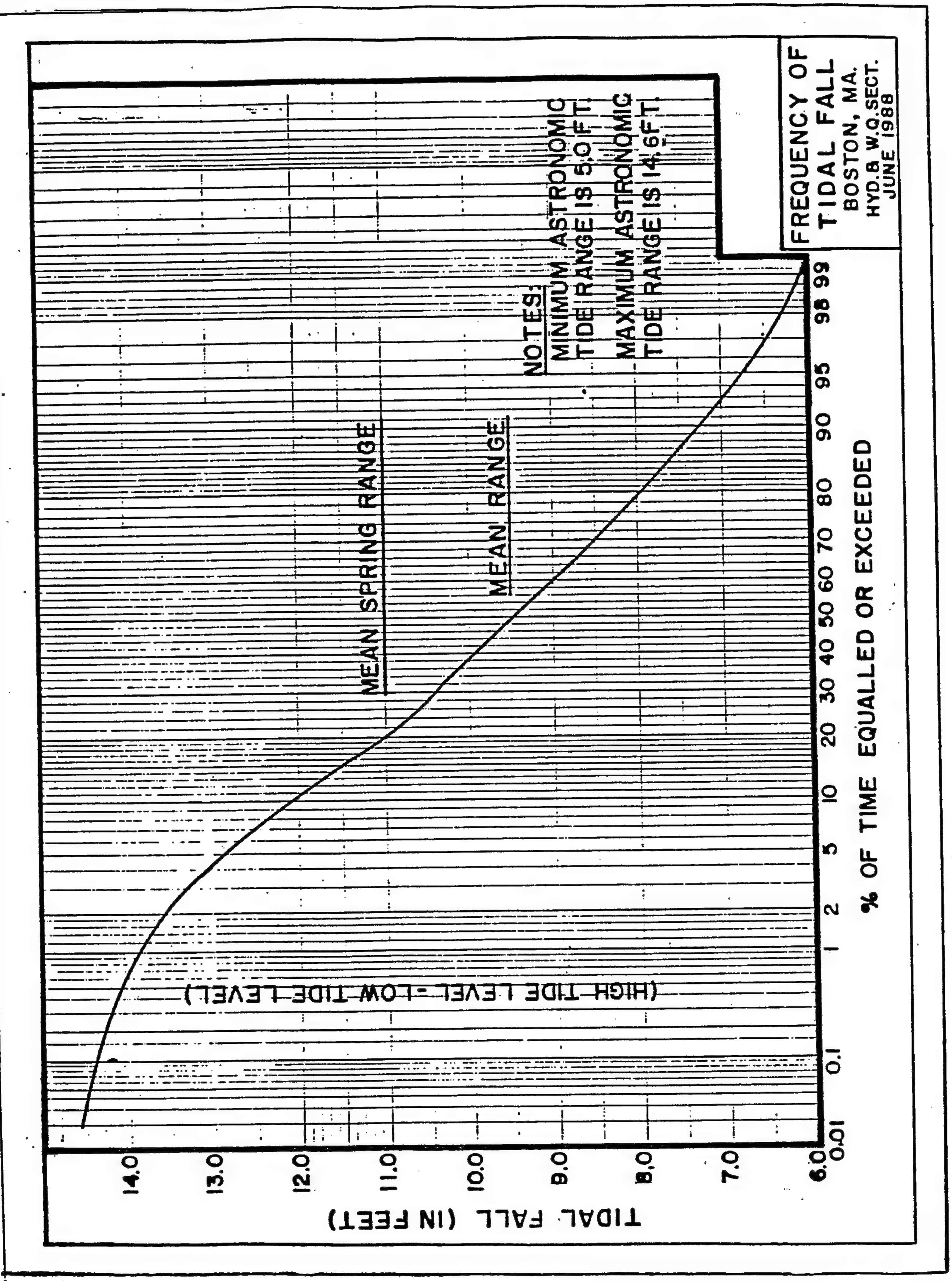
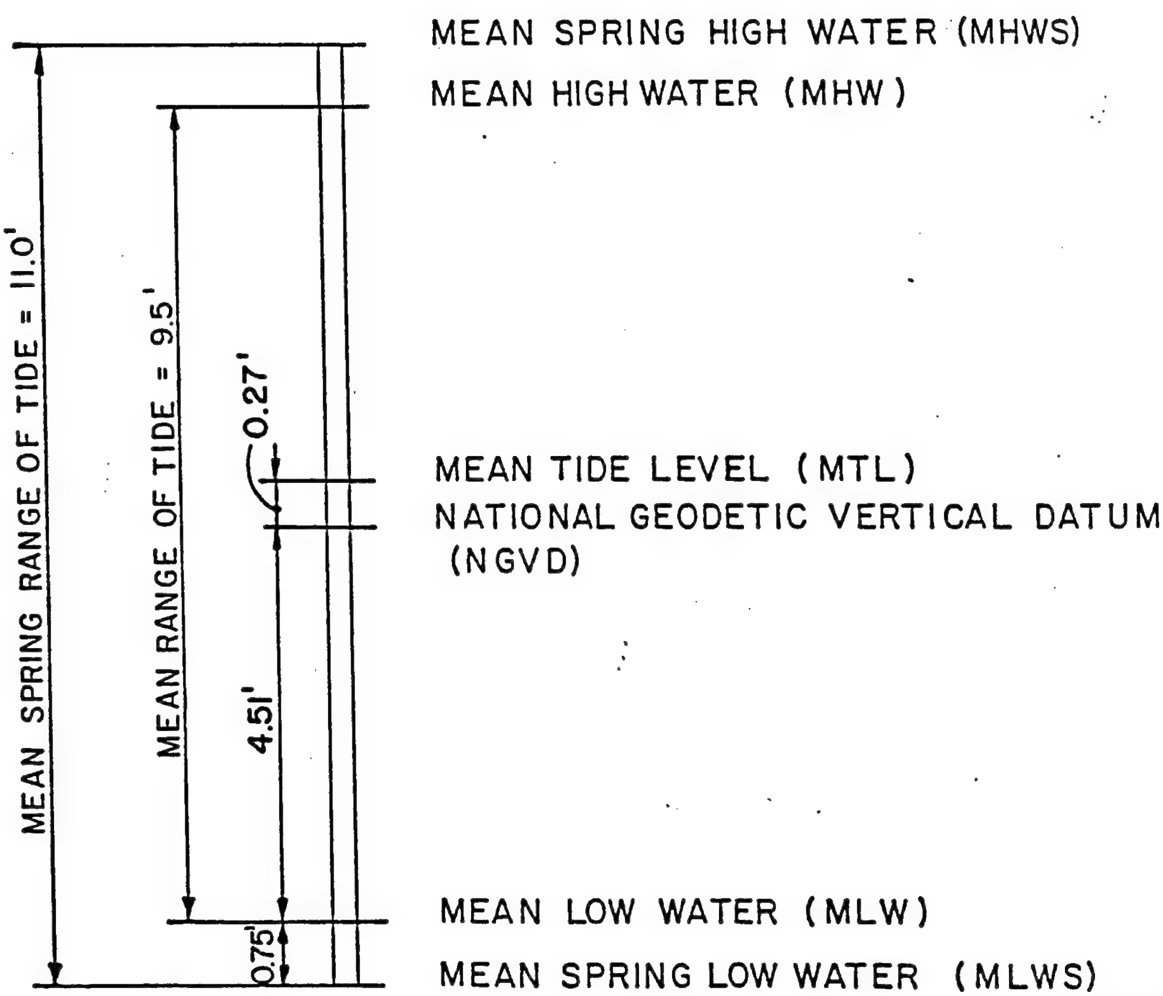

FREQUENCY OF TIDAL FALL
BOSTON, MA.
HYD.& W.Q. SECT.
JUNE 1988
NOTES:
MINIMUM ASTRONOMIC TIDE RANGE IS 5.0 FT.
MAXIMUM ASTRONOMIC TIDE RANGE IS 14.6 FT.
MEAN SPRING RANGE
MEAN RANGE
(HIGH TIDE LEVEL - LOW TIDE LEVEL)
TIDAL FALL (IN FEET)
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
% OF TIME EQUALLED OR EXCEEDED
0.01
0.1
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99

FIGURE D-2

TIDAL DATUM PLANES
BOSTON, MASSACHUSETTS
NATIONAL OCEAN SURVEY TIDE GAGE

(BASED UPON 1960-78 NOS TIDAL EPOCH)



NEW ENGLAND DIVISION
U.S. ARMY, CORPS OF ENGINEERS
WALTHAM, MASS. MARCH 1985

FIGURE D-3

TABLE D-3

BOSTON TIDAL DATUM PLANES
NATIONAL OCEAN SURVEY TIDE GAGE
(Based Upon 1960-78 NOS Tidal Epoch)

	Tide Level (ft, NGVD)
Maximum Predicted Astronomical High Water	7.5
Mean Spring High Water	5.8
Mean High Water (MHW)	5.0
Minimum Predicted Astronomical High Water	2.7
Mean Tide Level (MTL)	0.3
National Geodetic Vertical Datum (NGVD)	0.0
Maximum Predicted Astronomical Low Water	-2.4
Mean Low Water (MLW)	-4.5
Mean Spring Low Water (MLWS)	-5.2
Minimum Predicted Astronomical Low Water	-7.1

to the southeast of the New England coastline and the highest onshore windspeeds are from the northeast, these storms are called "northeasters" or "nor'easters" by New Englanders. As the storm approaches and passes, local wind directions may vary from southeast to slightly northwest. Coastlines exposed to these winds can experience high waves and extreme storm surge. Such storms are the principal tidal flood-producing events throughout the study area. Other storms, taking a more inland track, can have high winds from the southeast and are referred to as "southeasters." In the area under study, these storms do not generally produce as much storm surge and wave action as "northeasters" due to more limited fetch. The prime season for severe extratropical storms in New England is November through April.

(2) Tropical Cyclones. These storms form in a warm moist air mass over the Caribbean and waters adjacent to the West Coast of Africa. The air mass is nearly uniform in all directions from the storm center. Energy for the storm is provided by the latent heat of condensation. When the maximum windspeed in a tropical cyclone exceeds 75 mph, it is labeled a hurricane. Wind velocity at any position can be estimated, based upon the distance from the storm center and forward speed of the storm. The organized wind field may not extend more than 300 to 500 miles from the storm center. Recent hurricanes affecting New England generally have crossed Long Island Sound and proceeded landward in a generally northerly direction. However, hurricane tracks can be erratic. The storms lose much of their strength after landfall. For this reason, the southern coast of New England experiences the greatest surge and wave action from strong southerly to easterly flowing hurricane winds. However, on very rare occasions, reaches of coastline in eastern and northern New England may experience some storm surge and wave action from a weakened storm. Hurricanes have not been a principal cause of tidal flooding in the greater Boston area. The hurricane and tropical storm season in New England generally extends from August through October.

c. Winds. An estimate of windspeed is one of the essential ingredients in predicting wave heights. The most accurate estimate of winds at sea, which generate waves and propel them landward, is obtained by utilizing isobars of barometric pressure recorded during a given storm. However, actual recorded windspeed and direction data observed at a land-based coastal meteorological station can serve as a useful guide when more locally generated waves and currents are of interest. The disadvantage with using land-based wind records is that they may not be totally indicative of wind velocities at the sea-air interface where waves are

generated. However, often they are the only available source of information and adjustments must be made to develop over-water estimates from land-based records. Also, when estimating wave overtopping of coastal structures, it is necessary to utilize local wind conditions. These local winds help determine how much runup from breaking waves is blown over the structure.

(1) Percent Occurrence of Wind Direction and Speed. The National Weather Service (NWS) has recorded 31 years of hourly 1-minute average windspeed and direction data at Logan International Airport in Boston, Massachusetts, from 1945 through 1979. Logan Airport, adjacent to the study area, is the closest location to the project for which relatively complete, systematically recorded wind data are available. The windspeed data for this period alone were adjusted to a standard 33-foot observation height and 1-minute average windspeeds were converted to 1-hour average windspeeds. Since Logan International Airport is almost directly adjacent to the ocean, no land-to-sea conversion was applied. However, a wind stability correction was made for all fetches of interest. All adjustments were made in accordance with ETL 110-2-305 on the subject of determining wave characteristics on sheltered waters. Utilizing these one-hour average wind data, the percent occurrence of wind direction and windspeed range were computed. Since only onshore winds at the project are of interest, wind directions utilized in this analysis were limited to those between northeast (NE) and southeast (SE). This analysis, with results shown in table D-4 and figure 4, indicated that the principal onshore wind direction for windspeeds $\leq$ 5 mph is from the SE and for windspeeds > 5 and $\leq$ 15 mph, it is from the ESE Winds > 15 and $\leq$ 20 mph generally come from the East Winds > 20 mph come from the NE. The maximum average windspeed (11.8 mph) is from the NE, and the greatest maximum speed 68.7 mph from the SE. Overall average speed is 10.5 mph. Table D-4 also shows resultant wind direction for various windspeed ranges. The resultant wind direction is a vector quantity computed using the product of windspeed and direction. It is an indicator of net air movement past a given location. Overall, the resultant wind direction is from the East. However, winds > 20 mph have a more ENE resultant. The greatest percentage of windspeeds is shown to be > 10 and $\leq$ 15 mph.

(2) Windspeed Persistence. Additionally, actual windspeed persistence was determined on a directional basis. The resulting maximum windspeed persistence data, shown on figures 5(a) through 5(e), for directions northeast through southeast, indicate the maximum number of consecutive hourly

TABLE D-4

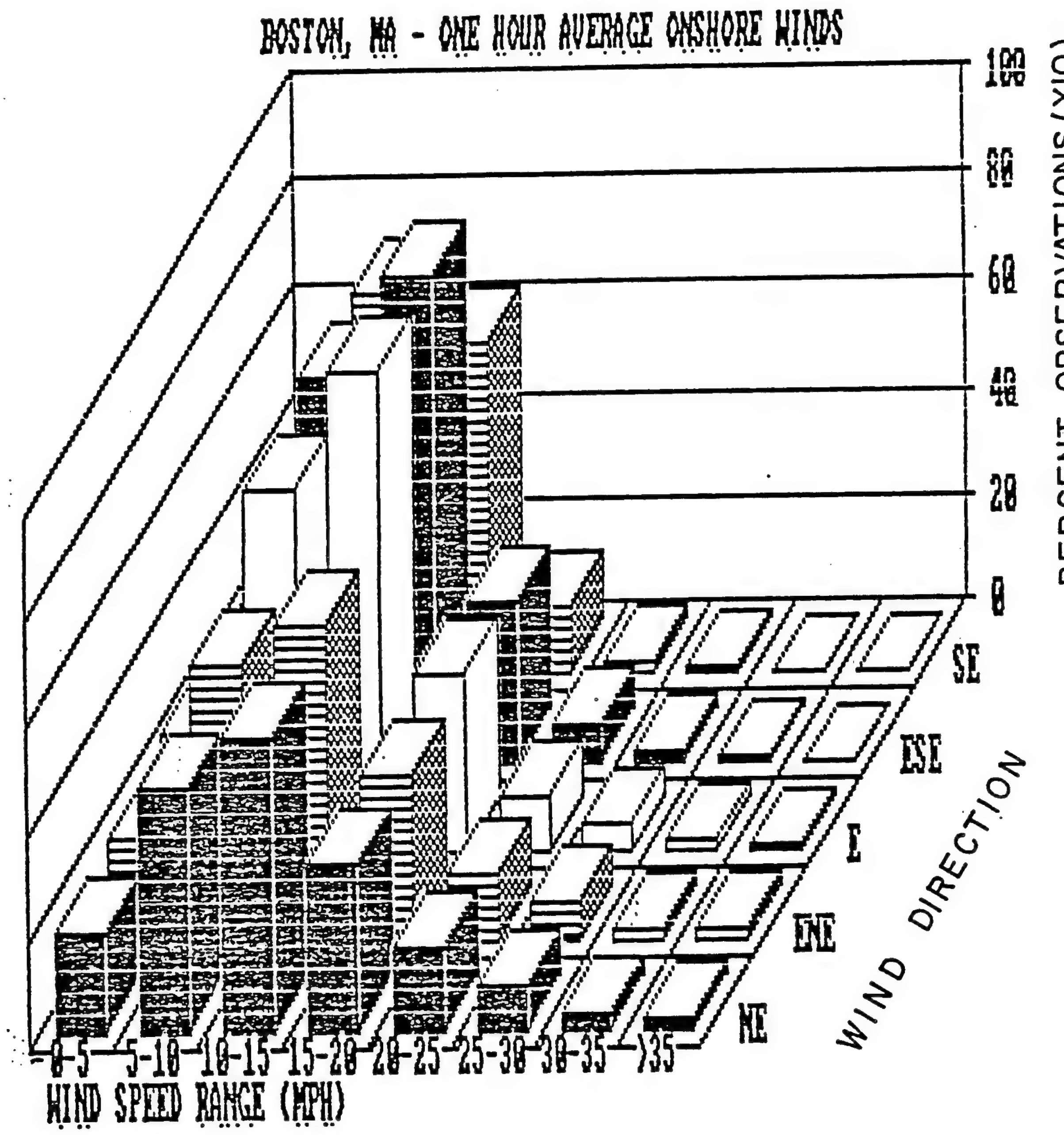
ADJUSTED HOURLY WIND OBSERVATIONS BETWEEN NE AND SE AT BOSTON, MASSACHUSETTS
(One-Hour Average Values)

PERCENT OF ONSHORE WINDSPEED AND DIRECTION OBSERVATIONS (X 10)

Direction	Windspeed Range (Miles Per Hour) 0-5	5-10	10-15	15-20	20-25	25-30	30-35	Over 35	All Inclusive	Avg Speed (mph)	Max Speed (mph)
NE	19	46	55	31	16	8	3	2	179	11.8	54.3
ENE	20	52	59	31	13	7	2	2	185	11.3	49.2
E	23	69	91	33	10	5	2	1	234	10.7	55.3
ESE	22	73	92	30	7	2	1	0	227	10.0	49.2
SE	24	72	63	13	2	1	0	0	174	8.7	68.7
NE-SE	108	313	360	136	48	22	7	5	1,000	10.5	68.7
Resultant Direction:	E	E	E	E	ENE	ENE	ENE	ENE	E		

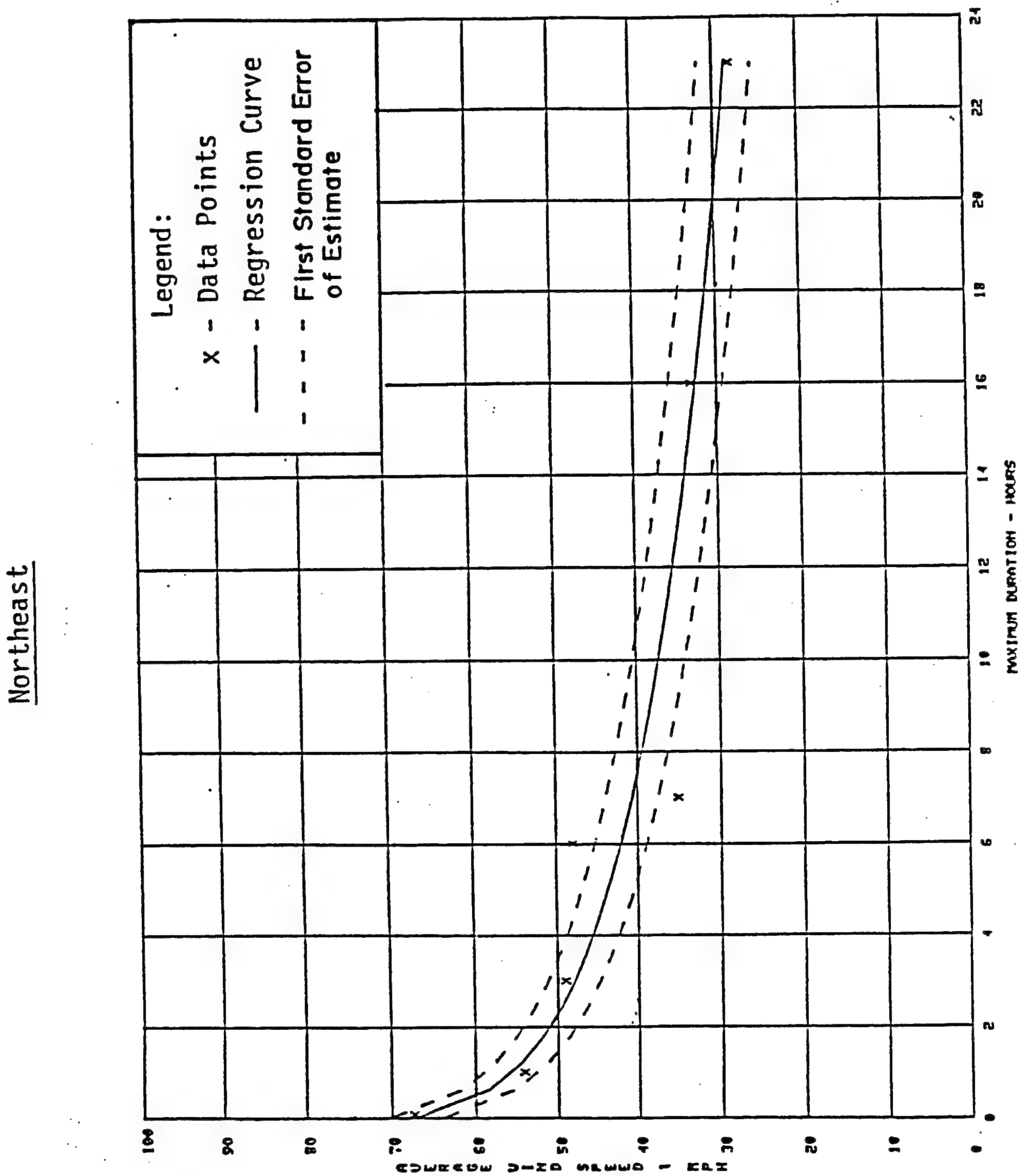
NOTES: 1. Windspeed ranges include values greater than the lower limit and less than or equal to the higher limit.

2. Onshore winds occur 21 percent of the time; therefore, average annual number of occurrence (A) = percent occurrence times 18.654 (for example: a windspeed range of 0-5 mph from the ENE, A = 2.0 (18.654) = 37).



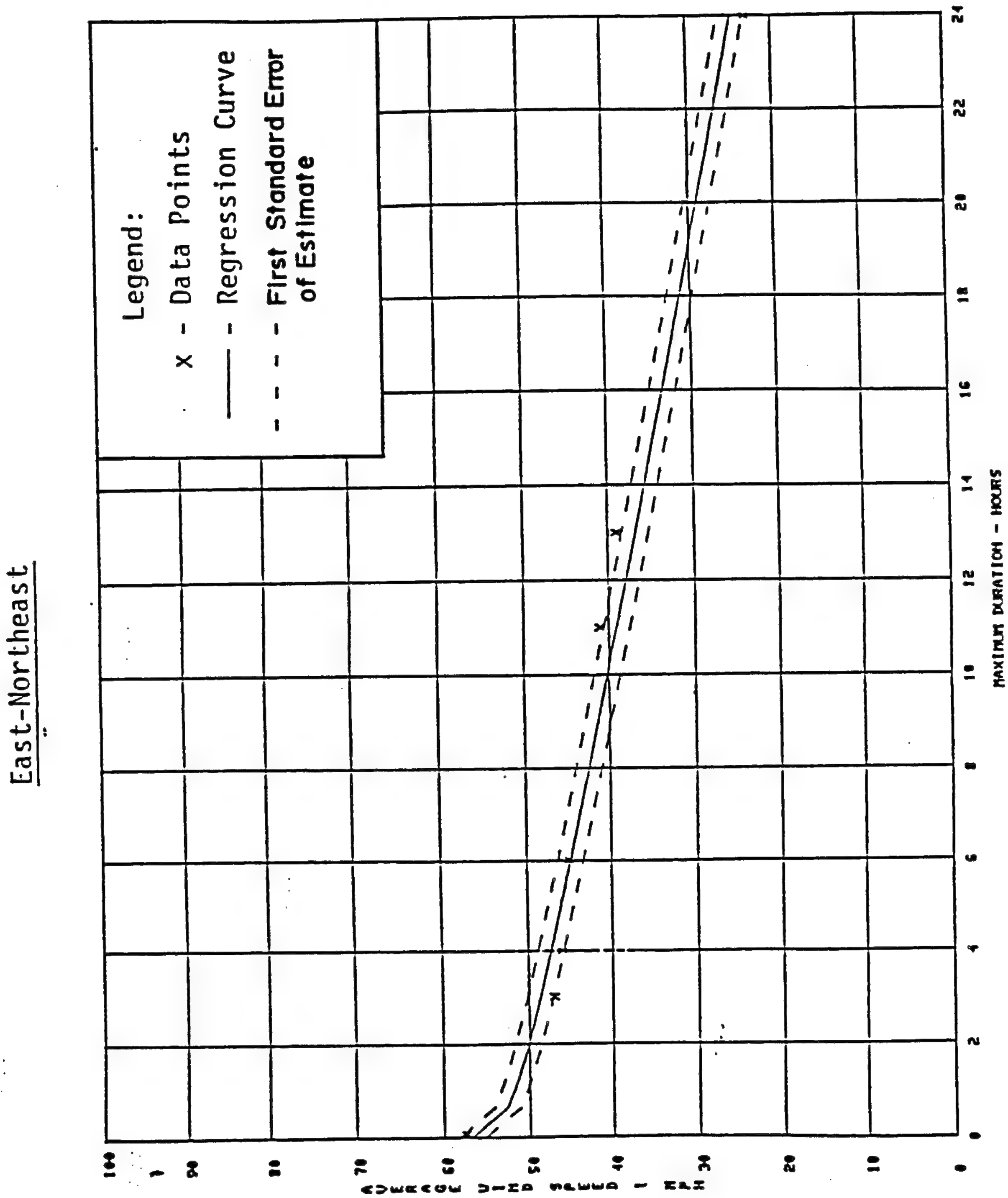
BOSTON, MA - ONE HOUR AVERAGE ONSHORE WINDS
100
80
60
40
20
0
PERCENT OBSERVATIONS (XIO)
SE
ESE
E
ENE
NE
WIND DIRECTION
0-5
5-10
10-15
15-20
20-25
25-30
30-35
>35
WIND SPEED RANGE (MPH)

FIGURE D-4



WIND PERSISTENCE
MEASURED AT BOSTON MA.
HYD. & W.Q. SECT. JUNE 1988

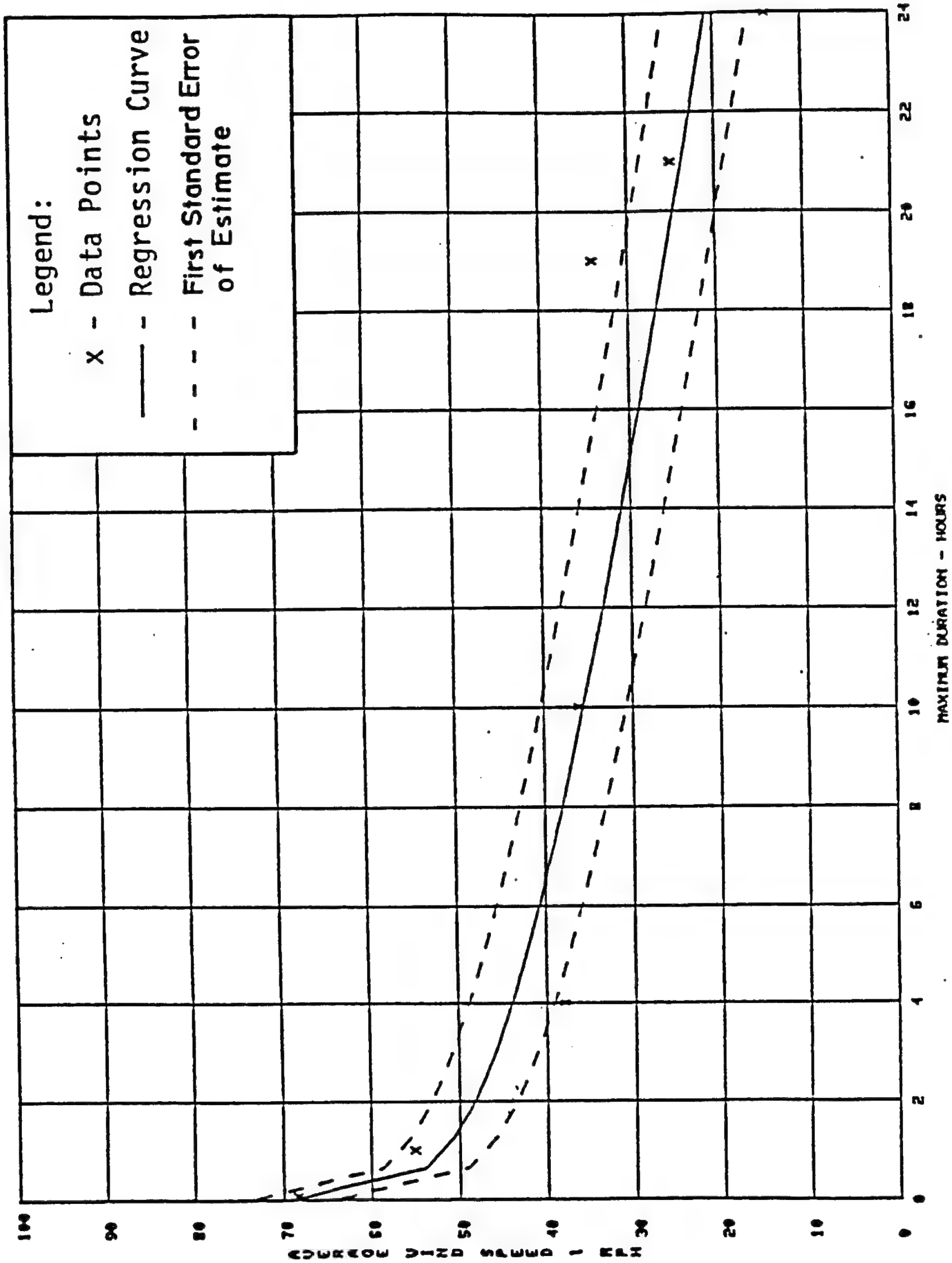
FIGURE D-5(a)



WIND PERSISTENCE
MEASURED AT BOSTON, MA.
HYD. & W.Q. SECT. JUNE 1988

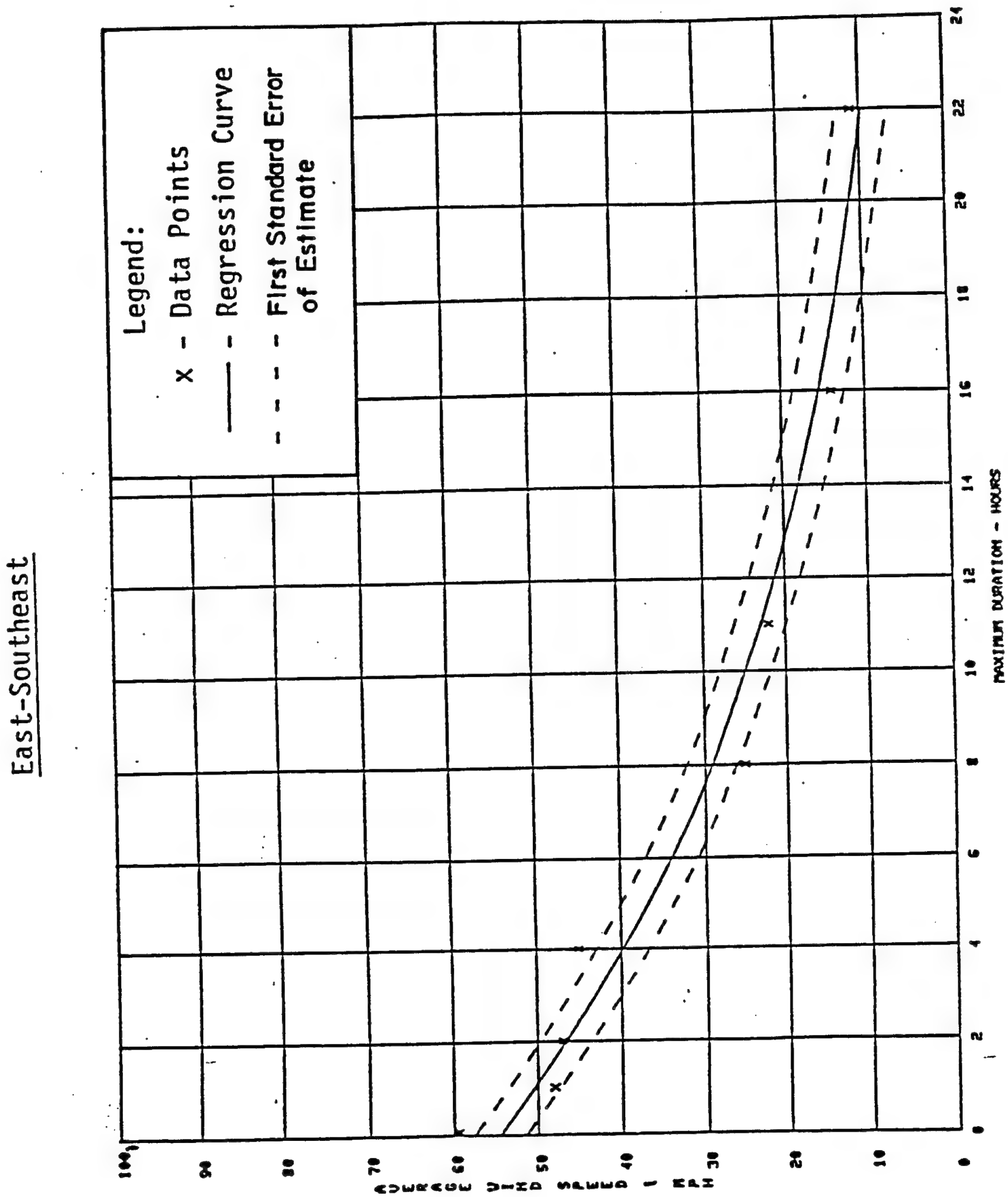
FIGURE D-5(b)

East



WIND PERSISTENCE
MEASURED AT BOSTON, MA.
HYD. & W.Q. SECT. JUNE 1988

FIGURE D-5(c)

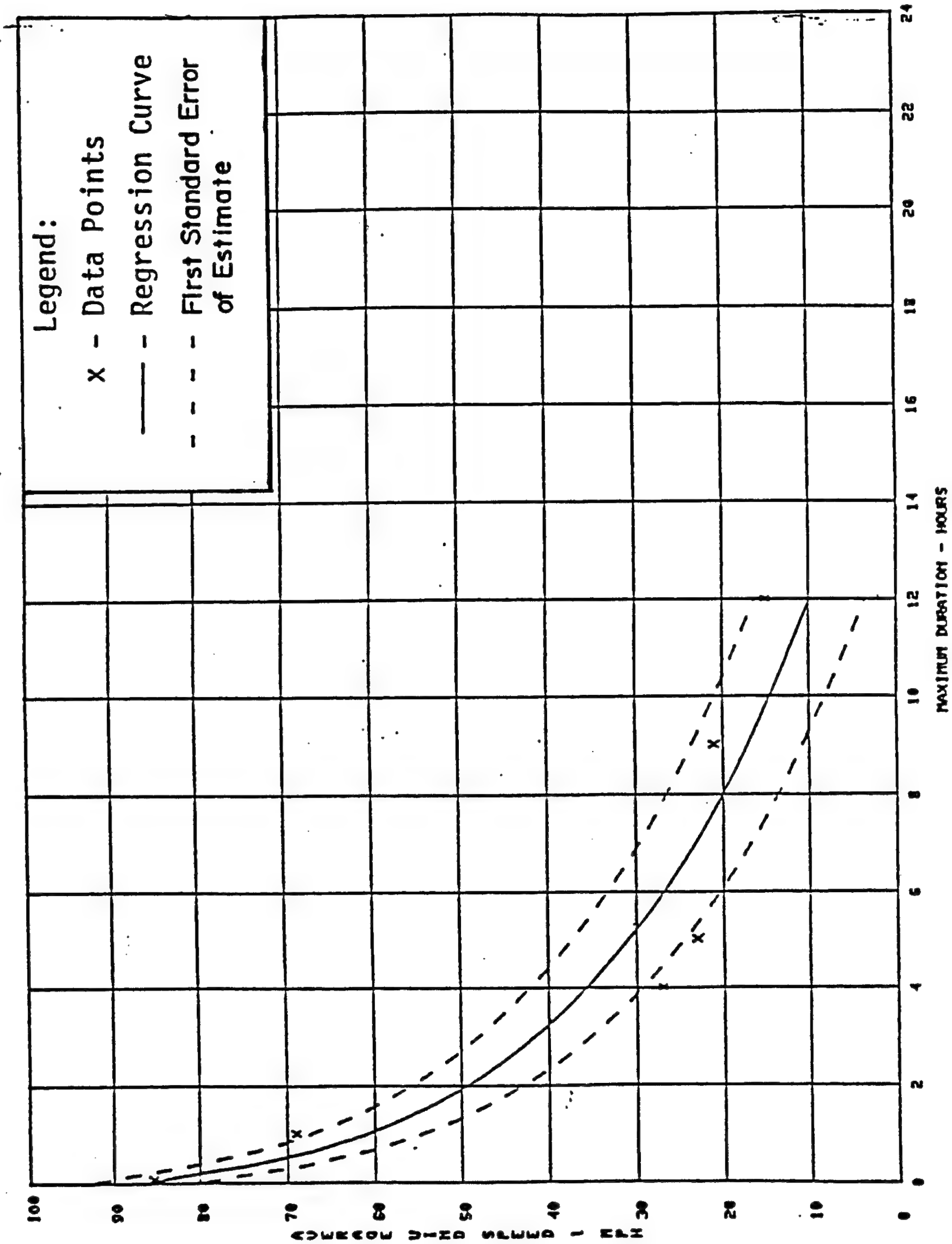


WIND PERSISTENCE
MEASURED AT BOSTON, MA.

HYD. & W.Q. SECT. JUNE 1988

FIGURE D-5(d)

Southeast



WIND PERSISTENCE
MEASURED AT BOSTON, MA.
HYD. & W.Q. SECT. JUNE 1988

FIGURE D-5(e)

windspeed observations that occurred at a given average speed from a particular direction. This analysis demonstrated that high onshore wind can occur for extended periods of time in the study area. High speed, long duration winds are usually associated with northeasters and, therefore, come from the northeastern quadrant. High intensity, short duration winds are from the southeast due to hurricane events. Of course, winds far out at sea can possess much greater speed and duration than reflected in land-based records.

(3) Winds During Historic Storms. When studying overtopping of coastal structures, it is useful to examine wind conditions during past flood events in order to obtain an appreciation for the possible severity of experienced wave overtopping conditions. Table D-5 presents National Weather Service (NWS) wind observations recorded at Logan Airport in Boston during notable tidal floods. From the data, it can be observed that the strongest winds recorded during flood events generally originated from directions between northeast and east. The greatest fastest-mile (approximately equal to 1-minute average speed) listed, 61 mph from the northeast, was recorded on 6 February 1978 during the great "Blizzard of '78." By comparing table D-5 with D-8, stillwater tide levels recorded during these storm events ranged between 10.4 and 8.2 feet, respectively. However, extremely severe onshore winds have occurred during storm events producing significantly lower observed maximum stillwater tide levels in the study area.

Since the astronomical tide range at the project is so variable, as explained in section 4a, many severe coastal storms occur during periods of relatively low astronomic tides. Thus, even though a storm may produce exceptionally high onshore winds, waves, and a tidal surge, the resulting tide level may be less than that occurring during a time of high astronomic tide and little meteorological influence. Table D-6 presents wind data recorded at Logan Airport during storms producing annual maximum surge values of 3 feet or more. For comparison, table D-7 lists maximum annual storm surges determined by the NWS in their "Tide Climatology For Boston, MA," November 1982, and associated observed tide levels. It can be seen that recurrence intervals of the maximum observed tide levels recorded on days of maximum annual storm surge were generally less than one year, with only a few storms producing significant tidal flood levels. (There may be some slight discrepancies in levels reported by the NWS in 1982 and more recent data from NOS due to corrections by NOS in some data records.) The recent storm of 30 October 1991 had a storm surge of 5.1 feet, greater than any shown in table D-7.

TABLE D-5

BOSTON - LOGAN INTERNATIONAL AIRPORT
NATIONAL WEATHER SERVICE
WIND OBSERVATIONS RECORDED
DURING NOTABLE TIDAL FLOODS

Date	Resultant Direction	Resultant Speed (mph)	Average Speed (mph)	Fastest-Mile Speed (mph)	Fastest-Mile Direction
06 Feb 1978	ENE	28.4	29.3	61	NE
29 Dec 1959	NE*	--	20.7	34	E
02 Jan 1987	N	15.5	21.8	35	NE
25 Jan 1979	ENE	23.2	24.2	45	E
30 Oct 1991	NNE	25.8	26.5	37	NE
19 Feb 1972	NE	21.1	24.2	47	NE
21 Apr 1940	-	--	13.3	43**	NE
12 Dec 1992	NE	31.8	32.1	51	NE
30 Nov 1944	-	--	13.4	48**	NE
25 May 1967	NE	34.3	34.7	50	NE
20 Jan 1961	NNW*	--	26.7	41	NNE
16 Mar 1956	ENE*	--	28.1	54	NE
06 Apr 1958	WSW*	--	13.8	32	SSE
16 Mar 1976	ENE	15.4	20.4	35	NE
07 Mar 1962	NE*	--	31.6	42	ENE
26 Feb 1979	NE	19.1	19.6	30	NE
02 Dec 1974	ENE	15.7	20.7	38	E
27 Feb 1952	N	--	17.4	40	NE

* Resultant speed and direction not available for the period prior to 1964; direction shown is prevailing wind direction.

** Fastest mile not available; volume shown is five-minute average speed.

NOTE: Listing is in order of decreasing observed stillwater tide level to provide uniformity with table D-8.

TABLE D-6

BOSTON - LOGAN INTERNATIONAL AIRPORT
NATIONAL WEATHER SERVICE
WIND OBSERVATIONS RECORDED
DURING ANNUAL MAXIMUM SURGE
PRODUCING STORMS
(1922-1979)

Date	Fastest Mile Speed (mph)	Fastest Mile Direction	Average Speed (mph)	Prevailing Direction
29 Nov 1945	63*	NE	40.5	-
13 Apr 1961	42	ENE	25.0	NE
06 Feb 1978	61	NE	29.3	ENE
14 Feb 1940	51*	NE	12.7	-
17 Nov 1935	54*	NE	14.9	-
19 Feb 1972	47	NE	24.2	NE
03 Mar 1947	50*	E	13.4	-
04 Mar 1960	45	NE	28.0	N
30 Jan 1966	43	S	22.3	SSE
12 Nov 1968	54	NE	23.9	E
25 Jan 1979	45	E	24.2	ENE
22 Mar 1977	60	NE	19.3	E
25 Nov 1950	74	E	42.4	E
31 Aug 1954	86	SE	31.8	ENE
16 Feb 1958	45	E	28.0	E
15 Nov 1962	37	NW	28.5	NW
16 Mar 1956	54	NE	28.1	ENE
27 Dec 1969	26	E	17.3	WNW
11 Mar 1924	--	-	--	-
30 Jan 1939	43*	NE	12.7	-
17 Feb 1952	50	NE	29.8	NE
07 Mar 1923	--	-	--	-
20 Feb 1927	--	-	--	-
19 Jan 1936	40*	NE	12.6	-
07 Nov 1953	67	NE	30.5	NE
14 Aug 1971	18	E	9.6	E
28 Jan 1973	23	NE	19.4	NE
12 Mar 1959	42	ESE	23.9	SE
16 Apr 1929	--	-	--	-
08 Mar 1931	--	-	--	-

* Fastest mile not available; value shown is five-minute average speed.

NOTE: Listing in order of decreasing annual maximum storm surge to allow comparison with table D-7.

TABLE D-7

ANNUAL MAXIMUM STORM SURGE
BOSTON, MASSACHUSETTS
(1922-1979)

Date	Annual Maximum Storm Surge (feet)	Maximum Observed Tide Level for the Day (feet, NGVD)	Recurrence* Interval (years)
30 Nov 1945	4.9	7.6	LT 1
13 Apr 1961	4.7	8.0	1
06 Feb 1978	4.6	10.0	50
14 Feb 1940	4.2	5.0	LT 1
17 Nov 1935	4.1	6.5	LT 1
19 Feb 1972	4.0	9.1	7
03 Mar 1947	3.8	7.2	LT 1
04 Mar 1960	3.8	8.1	2
30 Jan 1966	3.8	5.5	LT 1
12 Nov 1968	3.7	7.7	LT 1
25 Jan 1979	3.7	9.2	10
22 Mar 1977	3.6	5.3	LT 1
25 Nov 1950	3.6	6.4	LT 1
31 Aug 1954	3.5	8.2	2
16 Feb 1958	3.5	7.9	1
15 Nov 1962	3.5	7.9	1
16 Mar 1956	3.4	5.6	LT 1
27 Dec 1969	3.3	6.7	LT 1
11 Mar 1924	3.2	6.2	LT 1
31 Jan 1939	3.2	6.9	LT 1
18 Feb 1952	3.2	7.9	1
07 Mar 1923	3.1	6.9	LT 1
20 Feb 1927	3.1	6.9	LT 1
19 Jan 1936	3.1	5.9	LT 1
07 Nov 1953	3.0	7.4	LT 1
14 Aug 1971	3.0	5.4	LT 1
29 Jan 1973	3.0	6.1	LT 1
12 Mar 1959	2.9	6.5	LT 1
16 Apr 1929	2.8	6.6	LT 1
08 Mar 1931	2.8	6.5	LT 1

* Recurrence interval of observed tide elevations. Obtained from tide stage-frequency relationship, figure D-8.

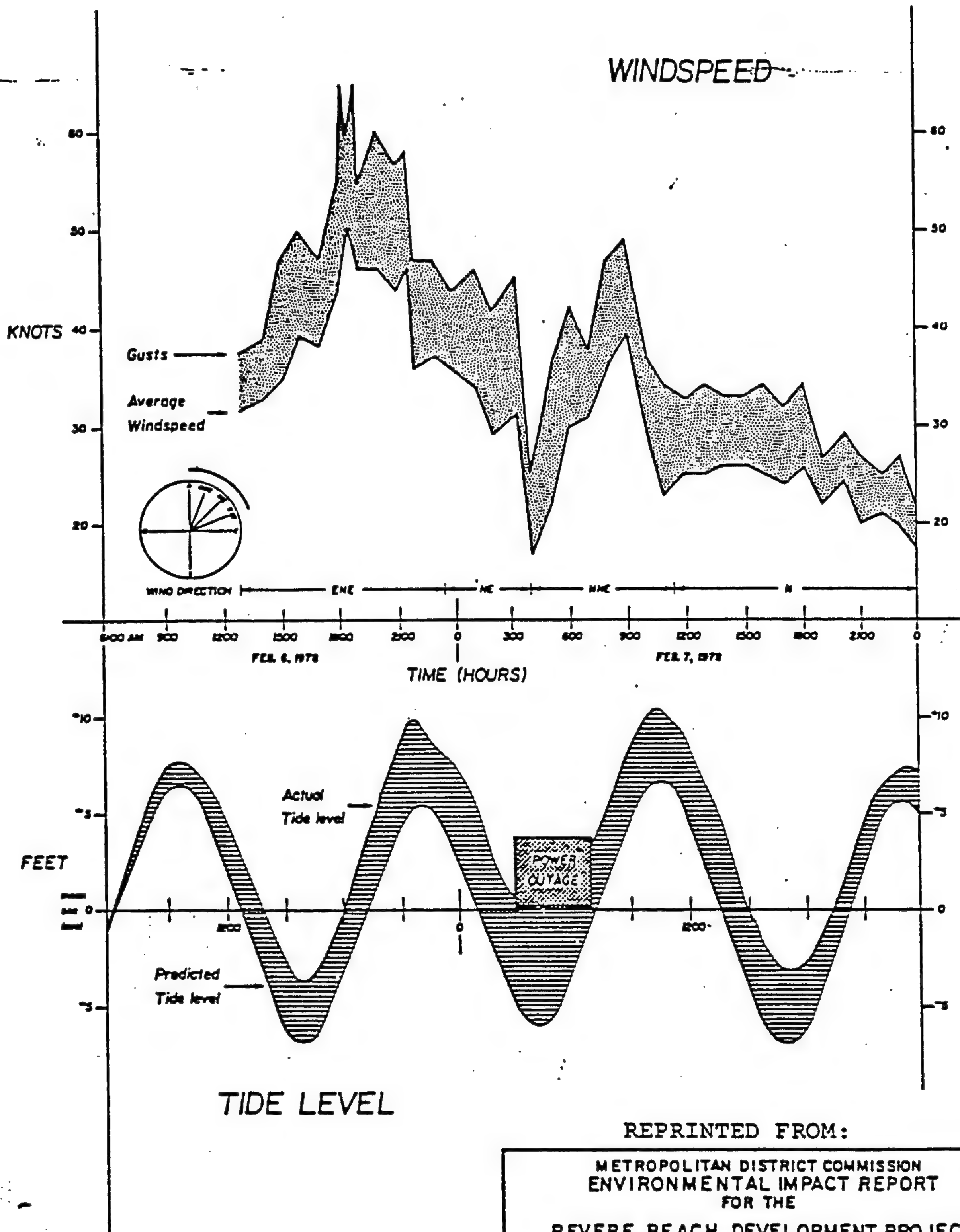
Some of the most severe onshore winds, waves, and storm surges have produced minor tidal flooding, owing to their coincidence with low astronomic tides. An example of this is the 30 November 1945 event, producing near-record storm surge at Boston; extremely high onshore winds occurred during a low astronomic tide and resulted in only a minor stillwater tidal flood level (7.6 feet NGVD).

Conversely, rather significant tidal flood levels can result from the coincidence of relatively high astronomic tides and relatively minor meteorological events. Astronomic high tide level in Boston alone can reach 7.5 feet NGVD (see table D-3). With such a condition, a coincident storm surge of only 2 to 3 feet can produce major tidal flood levels. The 7 February 1978 storm tide at Boston reached 10.4 feet NGVD, the greatest of record, but was produced by a combination astronomic tide of 6.9 feet NGVD and surge of 3.5 feet, the latter being of only moderate magnitude (see table D-7, which shows a surge of 3.5 feet is not extreme).

Windspeed observations recorded by the NWS at Boston's Logan Airport during the great blizzard of '78 are shown on figure D-6. There were gusts from the ENE in excess of 55 knots (63 mph) for approximately four hours. Average windspeeds from the same direction were sustained above 43 knots (49 mph) for nearly four hours.

d. <u>Storm Tides</u>. The total effect of astronomical tide combined with storm surge produced by wind, wave, and atmospheric pressure contributions is reflected in actual tide gage measurements. Since the astronomical tide is so variable at the study area, time of occurrence of the storm surge greatly affects the magnitude of the resulting tidal flood level. Obviously, a storm surge of 3 feet, occurring at a low astronomical tide, would not produce as high a water level as one occurring at a higher tide. It is important to note the storm surge itself varies with time, thus introducing another variable into the makeup of the total flood tide.

(1) <u>Boston</u>. The variation in observed tide and surge at Boston during the "Blizzard of '78" is shown in figure D-7. It is interesting to note the maximum surge (4.7 feet) occurred just before 10 p.m. on 6 February. However, the maximum observed tide occurred about 10:30 a.m. the following day when the surge had dropped by 1.2 feet. Had the maximum surge recorded during the storm occurred at 10:30 a.m. on 7 February, the observed tide would have been 11.6 feet NGVD, and would have resulted in even more catastrophic flooding at the project area. Annual maximum surge values of greater than or equal to 3.0 feet measured at the



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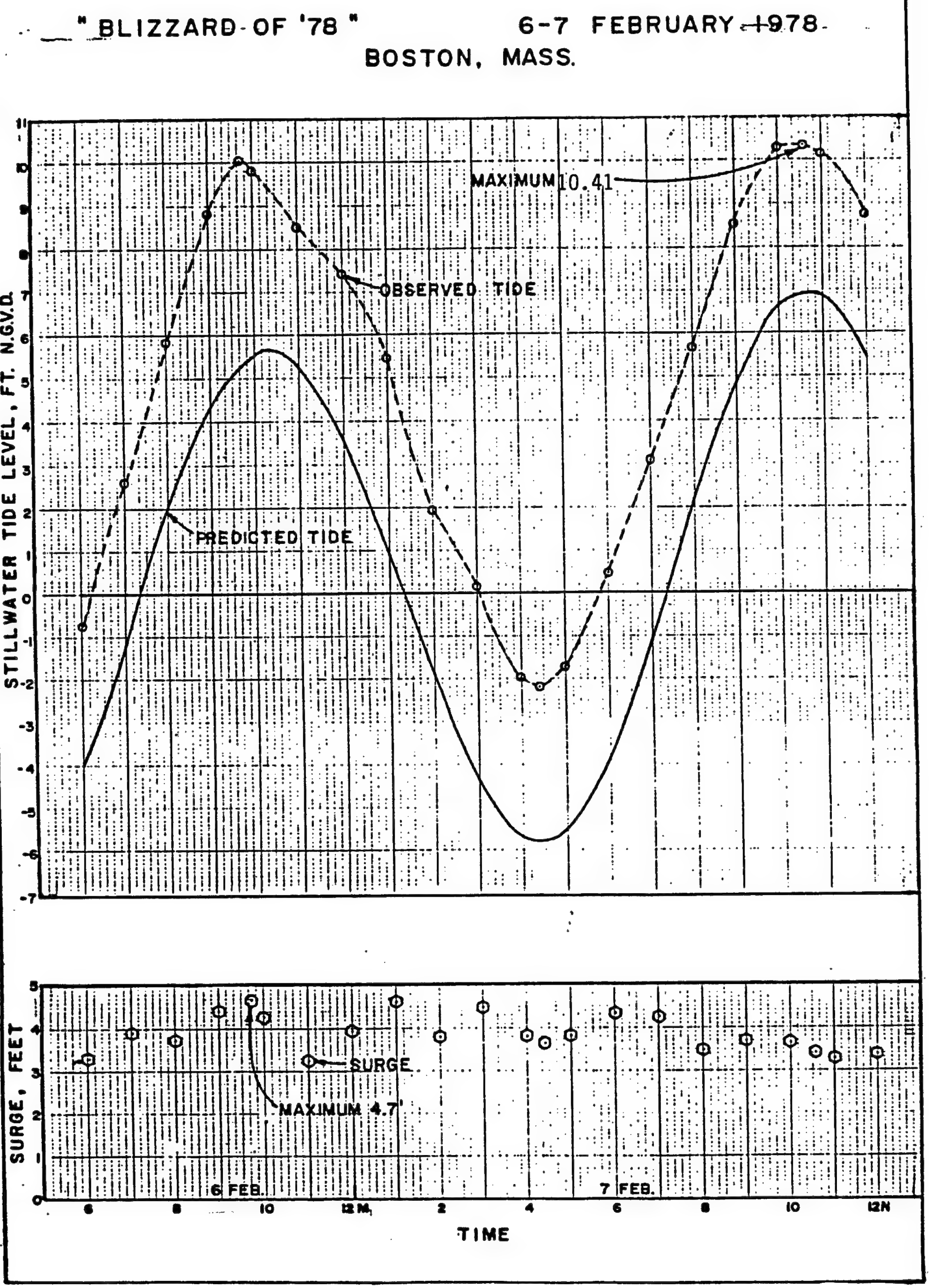
METROPOLITAN DISTRICT COMMISSION
ENVIRONMENTAL IMPACT REPORT
FOR THE
REVERE BEACH DEVELOPMENT PROJECT

TIDE LEVEL AND WINDSPEED VS. TIME FOR THE STORM OF FEBRUARY 6 AND 7, 1978.

Camp, Dresser & McKee, Inc.

Alan M. Voorhees & Assoc., Inc. Bolt Beranek & Newman, Inc.

FIGURE D-6



"BLIZZARD OF '78" 6-7 FEBRUARY 1978
BOSTON, MASS.
STILLWATER TIDE LEVEL, FT. N.G.V.D.
MAXIMUM 10.41
OBSERVED TIDE
PREDICTED TIDE
SURGE, FEET
SURGE
MAXIMUM 4.7'
6 FEB.
7 FEB.
6
8
10
12 M.
2
4
6
8
10
12N
TIME

FIGURE D-7

Boston, Massachusetts, National Ocean Survey (NOS) tide gage are shown on table D-7. The average annual maximum storm surge at Boston is 3 feet. This table shows the importance of coincident astronomic tide in producing significant tidal flooding (see the discussion in section 4c, which deals with the wind observations recorded during these events).

The NOS has systematically recorded tide heights at Boston, Massachusetts since 1922. The record prior to that time was developed, utilizing staff gage measurements and historical accounts. Maximum observed stillwater tide heights (measurements taken in protected areas in which waves are dampened out), recorded through 1992, are shown in table D-8. Also shown are tide heights with an adjustment applied to account for the effect of rising sea level (see section 14). The greatest observed stillwater tide level recorded occurred during the "Great Blizzard of '78." No hurricanes or tropical storms are known to have produced extreme tide heights at Boston, thus indicating that historically the principal threat of flooding in the study area is due to storms of the extratropical variety.

(2) Study Area. Storm tides at Nantasket are very close to those observed at the Boston NOS gage.

e. Tide-Stage Frequency

(1) Boston. A tide stage-frequency relationship for Boston was developed in 1992 utilizing a composite of (a) a Pearson type III distribution function, with expected probability adjustment, for analysis of historic and systematically observed annual maximum stillwater tide levels, and (b) a graphical solution utilizing Weibull plotting positions for partial duration series data (reference: EM 1110-2-1412, 15 April 1986). Corrections to previous NOS tide data, the occurrence of two major coastal storms, and the release of a new NOS report on sea level rise in 1988 prompted this reanalysis from previous studies in 1979. Due to greater confidence in sea level rise estimated since 1922, the recent systematic curve was adopted. However, plotting positions including historic data were used for descriptive purposes. The resulting tide stage-frequency curve is shown on figure D-8.

TABLE D-8

MAXIMUM STILLWATER TIDE HEIGHTS
BOSTON, MASSACHUSETTS

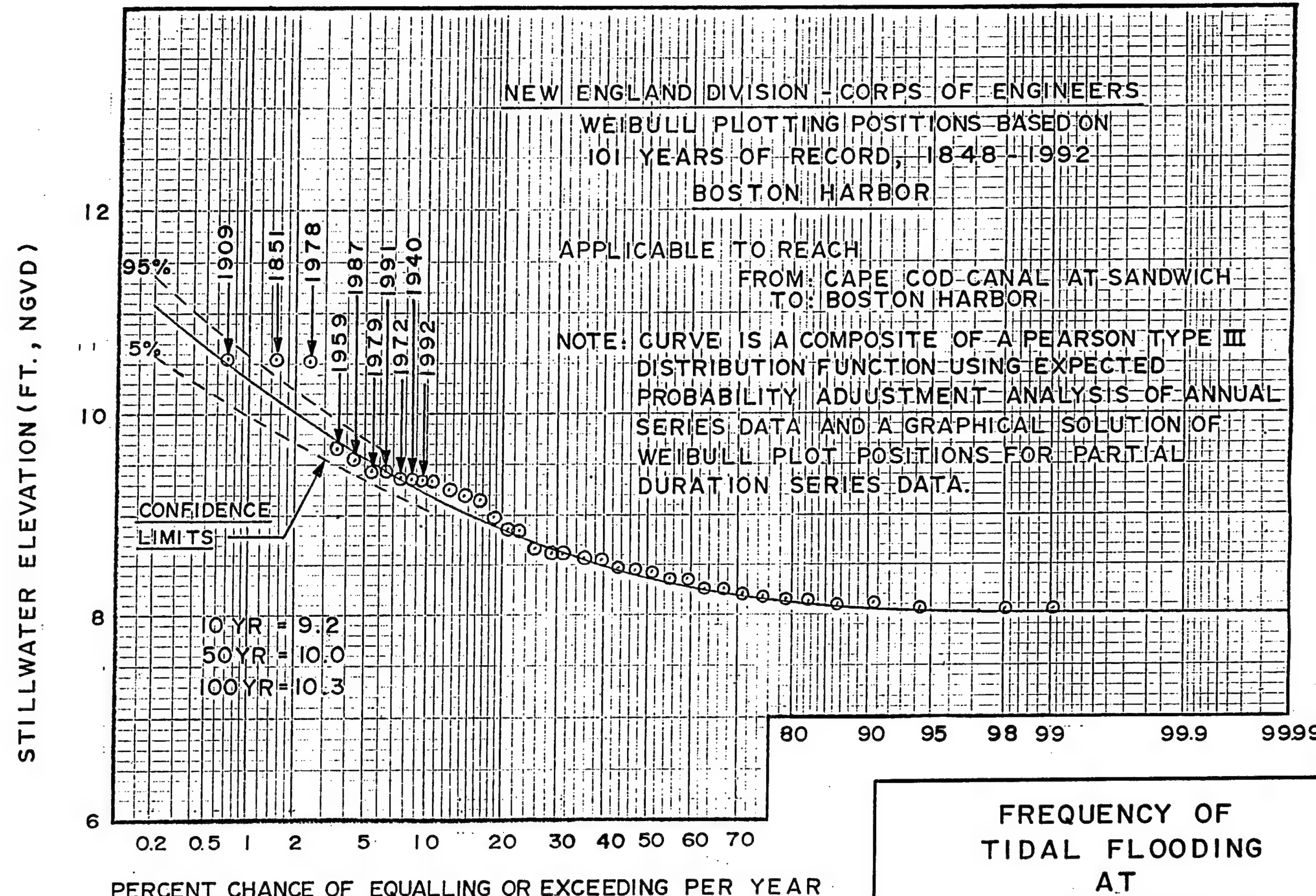
Date	Observed Elevation (feet, NGVD)	Adjusted Elevation* (feet, NGVD)	Weibul Plotting Position*** (percent)
26 Dec 1909	9.9	10.6	0.7
16 Apr 1851	10.1	10.5	1.5
07 Feb 1978	10.4	10.5	2.5
29 Dec 1959	9.4	9.7	3.5
02 Jan 1987	9.5	9.5	4.5
25 Jan 1979	9.3	9.5	5.5
30 Oct 1991	9.4	9.5	6.5
19 Feb 1972	9.2	9.4	7.4
21 Apr 1940	8.9	9.4	8.2
12 Dec 1992	9.4	9.4	9.4
29 Dec 1853**	8.9	9.3	10.4
04 Mar 1931	8.8	9.3	11.4
03 Dec 1854**	8.8	9.3	12.4
30 Nov 1944	8.8	9.2	13.3
26 May 1967	9.0	9.2	14.3
03 Nov 1861**	8.7	9.2	15.7
20 Jan 1961	8.9	9.1	16.7
15 Nov 1871**	8.5	9.1	17.7
23 Nov 1858**	8.5	9.0	18.6
17 Mar 1956	8.6	9.0	19.6
07 Apr 1958	8.6	8.9	20.6
16 Mar 1976	8.7	8.9	21.6
28 Jan 1933	8.3	8.8	22.6
31 Dec 1857**	8.3	8.8	23.5
07 Mar 1962	8.5	8.7	24.5
06 Jan 1856**	8.2	8.7	25.5
09 Jan 1868**	8.1	8.6	26.5
21 Nov 1851**	8.2	8.6	27.5
07 Mar 1864**	8.1	8.6	28.4
26 Feb 1979	8.5	8.6	29.4
02 Dec 1974	8.4	8.6	30.4
12 Nov 1947	8.2	8.6	31.4

* Observed values after adjustment for changing mean sea level; adjustment made to 1992 mean sea level.

** Approximate values based on historical account.

*** Weibul plotting position of adjusted elevation with annual series/partial duration adjustment for 101 years of record, 1848-1992 (1 high outlier).

NOTE: Events occurring within about 30 days of a greater tide producing event are exluded from this list. Events recorded during years for which only partial records are available were also excluded.



FREQUENCY OF
TIDAL FLOODING
AT
BOSTON HARBOR

CJW

MAR. 93

FIGURE D-8

(2) <u>Study Area</u>. NOS tide gage records and high watermark data have been gathered after major storms were utilized in the development of profiles of tidal floods along the New England coast. Additionally, profiles of storm tides for selected recurrence intervals have been developed, utilizing tide stage-frequency curves and high watermark information. A location map and profile for the reach of New England coast bounding the project are shown in figures D-9 and D-10, respectively. These generally show stillwater storm tides to be similar between Boston and Nantasket.

5. TIDAL HYDRAULICS

a. <u>Standard Project Northeaster (SPN) Tide Level</u>. Although wave overtopping was not conducted for the SPN at Nantasket, an SPN has been defined for an adjacent area at Revere, Massachusetts and is described as follows: Previous analysis conducted during the feasibility investigation for the nearby Roughans Point project in Revere, Massachusetts, resulted in an estimated ocean stillwater tide level of 13.0 feet NGVD for the SPN. OCE approved use of this estimated value, pending formal development of the SPN tide level (reference: DAEN-CWE-H, 17 November 1980, 1st Ind, "Hydrologic Criteria - Revere, Massachusetts Coastal Flood Protection"). During a subsequent meeting between NED, WES, and OCE, it was agreed that a less formal analysis of the SPN would be conducted by WES for use in the Revere area, along with physical and mathematical modelling of wave overtopping at Roughans Point (reference: DAEN-CWH-Y, 5 March 1984, 1st Ind and NEDED-WQ, 11 April 1984, 2nd Ind, "Hydrologic Criteria - Roughans Point Coastal Flood Protection, Revere, Massachusetts"). The following presents a discussion WES' evaluation of the Standard Project Northeaster Tide Level.

The Standard Project Northeaster definition can be determined from the definition for the Standard Project Storm (EM 1110-2-1411) as the northeaster resulting from the "most severe combinations of meteorologic and tidal conditions that are considered reasonably characteristic of the geographical region involved, excluding extremely rare combinations." For this report, two processes are important in considering the specification of an SPN, stillwater level and wave overtopping. It is possible that a separate SPN would have to be defined for each process. The SPN which would produce the highest ocean stillwater level might not produce the highest waves in the study area and, therefore, not the highest overtopping rates.

The SPN stillwater level was estimated to be 13.0 feet NGVD in NED's feasibility studies for Revere by adding

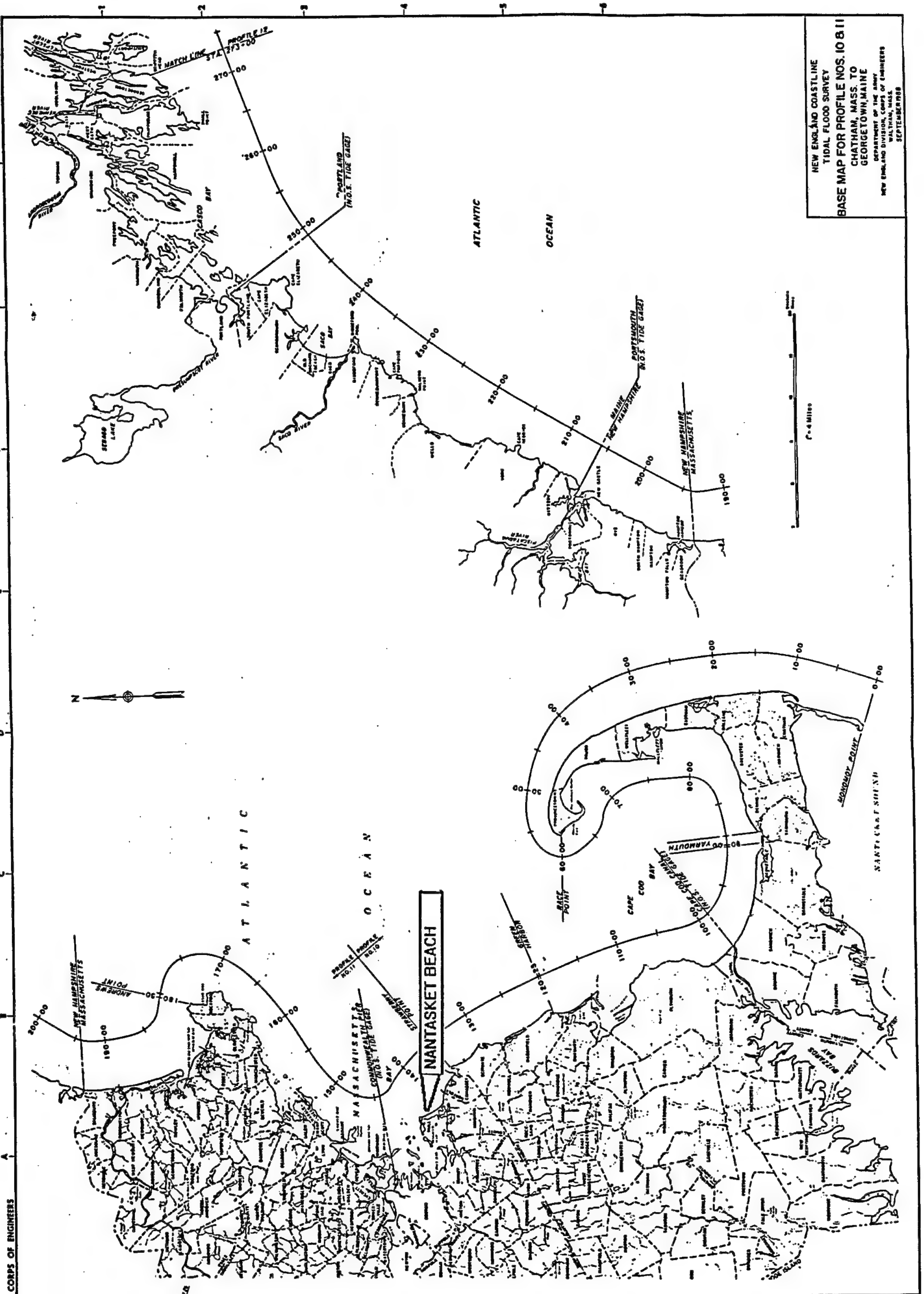

U.S. ARMY
CORPS OF ENGINEERS
NEW ENGLAND COASTLINE
TIDAL FLOOD SURVEY
BASE MAP FOR PROFILE NOS. 10 & 11
CHATHAM, MASS. TO
GEORGETOWN, MAINE
ATLANTIC
OCEAN
NANTASKET BEACH
CAPE
COD
BAY
MONOMOY POINT
RACE POINT
GREEN HARBOR
NEW HAMPSHIRE
MASSACHUSETTS
MAINE
CASCO
BAY
SACO
BAY
SEBAGO
LAKE
PORTLAND
(N.O.S. TIDE GAGE)
PORTSMOUTH
(N.O.S. TIDE GAGE)
MATCH LINE
ANDREWS POINT
STRAWBERRY POINT
YARMOUTH
PROFILE NO. 11
PROFILE NO. 10

FIGURE D-9

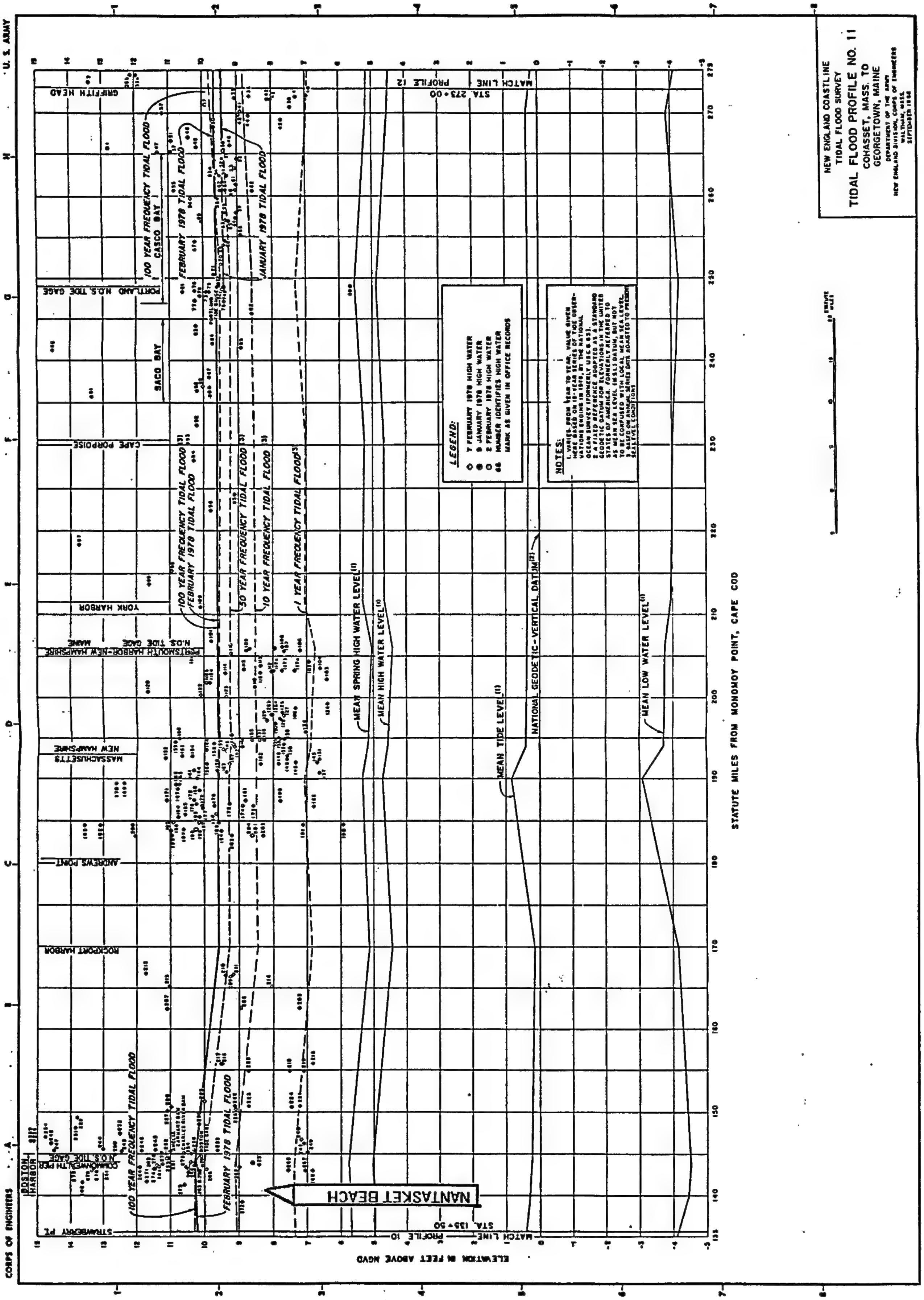

NEW ENGLAND COASTLINE
TIDAL FLOOD SURVEY
TIDAL FLOOD PROFILE NO. 11
COHASSET, MASS. TO
GEORGETOWN, MAINE
CORPS OF ENGINEERS
U. S. ARMY
ELEVATION IN FEET ABOVE NGVD
STATUTE MILES FROM MONOMOY POINT, CAPE COD
LEGEND:
7 FEBRUARY 1978 HIGH WATER
9 JANUARY 1978 HIGH WATER
2 FEBRUARY 1978 HIGH WATER
NUMBER IDENTIFIES HIGH WATER MARK AS GIVEN IN OFFICE RECORDS
NOTES:
NANTASKET BEACH
100 YEAR FREQUENCY TIDAL FLOOD
FEBRUARY 1978 TIDAL FLOOD
50 YEAR FREQUENCY TIDAL FLOOD
10 YEAR FREQUENCY TIDAL FLOOD
1 YEAR FREQUENCY TIDAL FLOOD
JANUARY 1978 TIDAL FLOOD
MEAN SPRING HIGH WATER LEVEL
MEAN HIGH WATER LEVEL
MEAN TIDE LEVEL
NATIONAL GEODETIC VERTICAL DATUM
MEAN LOW WATER LEVEL
MATCH LINE
PROFILE 10
STA. 135+50
PROFILE 12
STA. 273+00
STRAWBERRY PT.
BOSTON HARBOR
COMMONWEALTH PIER N.O.S. TIDE GAGE
ROCKPORT HARBOR
ANDREWS POINT
MASSACHUSETTS
NEW HAMPSHIRE
PORTSMOUTH HARBOR-NEW HAMPSHIRE N.O.S. TIDE GAGE
MAINE
YORK HARBOR
CAPE PORPOISE
SACO BAY
PORTLAND N.O.S. TIDE GAGE
CASCO BAY
GRIFFITH HEAD

FIGURE D-10

together the maximum surge recorded at Boston, approximately 5 feet, and the maximum predicted astronomic tide, 7.5 feet NGVD, and then rounding up to the next foot of elevation. This resulted in a stillwater ocean elevation almost 3 feet higher than the maximum ever recorded at the Boston gage. Given the unlikely event that a tide, with a maximum elevation near the maximum predicted astronomic tide, were to occur sometime during the maximum surge-producing northeaster, the probability that the hour of maximum surge (using hourly increments) would occur at the hour of maximum tide is only 1/24 (assuming a semidiurnal tide with unequal highs). Consequently, this combination might fall under the "excluding extremely rare" clause in the definition of the SPN. A better specification of the SPN stillwater level might be closer to 12.0 feet NGVD. Because of the close proximity of Revere to Nantasket, for purpose of this study, a revised SPN stillwater tide level of 12 feet NGVD has been adopted. Due to the limited flood protection provided by beach fill protection at Nantasket, no wave overtopping analysis was conducted for the SPN. If studies proceed, this will be added to the feasibility study.

b. Wave Height, Runup and Overtopping. As part of the reconnaissance investigation of Nantasket Beach and backshore area for flood protection, wave heights, wave runup and peak rates of overtopping were computed along the beach.

(1) Design Wave Heights. Design significant wave heights were calculated for deep water wave growth using the Automated Coastal Engineering System (ACES), version 1.06. This was based partly on information provided by the Coastal Engineering and Survey Section for:

(a) Storms entering from the east-northeast with fetch of 400 miles.

(b) Sustained windspeeds of 39, 37, 34, 29, 27, and 21 miles per hour from the same direction for a duration of 24 hours and having return periods of 100, 50, 25, 10, 5, and 2 years, respectively. Windspeed data was based on that presented in the General Design Memorandum, Revere Beach Erosion Control Project, August 1985 (revised June 1986).

Design wave heights and periods for fully developed waves at Nantasket Beach are shown in table D-9.

(2) Stillwater Tide Levels. Stillwater tide levels for return periods of 2, 5, 10, 25, 50, and 100 years were obtained from a previously developed Boston frequency curve established from a period of record that extended from 1848 to 1987. The stillwater tide levels derived from this curve

TABLE D-9
Wind Generated Waves
Nantasket Beach, Hull, MA

Retrun Period (Years)	Duration (Hours)	Wind Speed (MPH)	Fetch (MI)	Wave Height (FT)	Period (SEC)
100	24	39	400	24.1	14.3
50	24	37	400	22.2	13.7
25	24	34	400	19.4	12.8
10	24	29	400	15.2	11.3
5	24	27	400	13.6	10.7
2	24	21	400	6.6	7.5

Assumptions:
Deep water wave generation.
Winds from east northeast.
Fully developed seas.

for return periods of 25, 10, 5, and 2 years are 0.1 to 0.2 foot lower than those obtained from figure D-8, "Frequency of Tidal Flooding at Boston Harbor," derived from a period of record extending from 1848 to 1992. The latter curve includes error corrections and changed historic sea level rise rates by the National Ocean Service. The Boston curve is reasonably representative of Nantasket.

(3) Existing Conditions. In December 1992, surveyors profiled the 6,800 foot-long beach fronting the Metropolitan District Commission Reservation. Plate D-2 shows the nine reaches used for this hydraulic analysis. Reaches 1 and 2 span the northern end of the study area from the MDC Reservation limit at Phipps Street to the beginning of a riprap revetment. Except for a reinforced concrete wall fronting an MDC building, the beach is unprotected by a seawall in this area. Reach 3 is defined by a riprap revetment. The top elevation of the concrete seawall in reaches 4 through 9 varies from 15.8 to 17.0 feet NGVD. Sections of the continuous concrete wall were built and rebuilt at various times. The seawall starts at the southern end of riprap, and runs to the south along the shorefront until it ends at rock outcrops at Atlantic Hill. Access to the beach is provided by steps at approximately 14 locations. A typical access is evaluated at reach 5, where top of curb elevation is 15.1 feet NGVD.

The toe of structure was defined at the base of the seawall or the point where the structure slope intersected the nearshore slope. A nearshore slope of 1 vertical to 50 horizontal was assumed based on December 1992 beach profiles extending 400 to 500 feet seaward of the seawall. Depth of the structure was defined as the difference between the stillwater tide level associated with the particular return period and intersection elevation of the structure and nearshore slopes.

(4) Improvements to Existing Conditions. Assumptions for the sandfill included a 75-foot wide berm at elevation 12.5 feet NGVD. The proposed construction slope of 1 vertical on 15 was assumed to flatten over time to 1 on 20, and possible 1 on 30.

The proposed sandfill alternative for protecting Nantasket Beach was evaluated for runup and peak rates of overtopping. The structure toe was defined at the point where the proposed sandfill slope intersects the assumed nearshore slope of 1 vertical to 50 horizontal. Depth of the structure was defined as the difference between the stillwater tide level associated with the particular return

period, and elevation of the intersection of the structure and nearshore slopes.

Another alternative, a 7,000 foot-long offshore breakwater, was not evaluated for wave runup and overtopping due to its likely high cost.

(5) <u>Analysis of Wave Runup and Peak Overtopping Rate</u>. The Automated Coastal Engineering System (ACES), version 1.07 "Wave Runup and Overtopping on Impermeable Structures" was used to estimate wave runup and peak rates of overtopping along existing and proposed sandfill profile lines 1 through 9. For each particular return period, a local windspeed from the east-northeast perpendicular direction was assumed to be occurring during the period of wave runup and/or overtopping. Overtopping coefficients were estimated, using the Shore Protection Manual, 1984, and best engineering judgement.

The condition when waves break at the structure toe was assumed to be critical for analyzing wave runup and peak rates of overtopping of the existing wall for both the existing beachfill and the proposed new sandfill protection. The design wave height for each particular return period was compared to the height of the wave breaking at the structure toe. For return periods less frequent than 2 years, the design wave height was lowered until breaking at the structure toe was found to occur. Results of wave runup for particular return periods are shown in table D-10. Results of peak rates of overtopping are shown in table D-11.

(6) <u>Conclusions</u>. The proposed sandfill will provide substantial flood protection to the backshore area if it is maintained and remains in place over the project life. Initiation of significant overtopping, now nearly a 5-year event, will become a 50-year event at the proposed sandfill slope of 1 vertical on 15 horizontal and a 100-year event at the slopes of 1 on 20 and 1 on 30.

6. INTERIOR HYDROLOGY

a. <u>Description of Area</u>. Nantasket Beach is a Metropolitan District Commission (MDC) recreation park. The beach and seawall are overtopped by wind-generated waves that flood interior areas. The area under study consists of a narrow strip of land with an average width of 500 feet and a total length of 6,800 feet. The area is relatively flat with low elevations ranging between 15.6 to 10.8 feet NGVD and very little allowance for flood storage. When overtopping of the seawall occurs, a relatively small depth of ponding can

TABLE D-10

Wave Runup Data
Nantasket Beach, Hull, MA

Reach No.:	1	2	3	4	5	6	7	8	9
Length, LF:	400	825	1045	1450	50	1385	780	550	330
Wall Height: (Ft., NGVD)	16.9	16.1	16.5	16.3	15.1*	16.6	17.2	15.8	17.0
Slope (Exist-: & 3 proposed)	EX** 1:15 1:20 1:30	EX**1:15 1:20 1:30	EX**1:15 1:20 1:30	EX**1:15 1:20 1:30	EX**1:15 1:20 1:30	EX**1:15 1:20 1:30	EX**1:15 1:20 1:30	EX**1:15 1:20 1:30	EX**1:15 1:20 1:30
Stillwater Tide Level (Ft., NGVD)	Top Runup (Ft NGVD)	Top Runup (Ft NGVD)	Top Runup (Ft NGVD)	Top Runup (Ft NGVD)	Top Runup (Ft NGVD)	Top Runup (Ft NGVD)	Top Runup (Ft NGVD)	Top Runup (Ft NGVD)	Top Runup (Ft NGVD)
10.3	15.5 17.2 15.5 13.8	15.3 17.2 15.5 13.8	34.6 17.7 15.8 14.0	33.2 17.4 15.7 13.9	33.7 17.2 15.5 13.8	33.8 17.4 15.6 13.8	33.8 17.4 15.6 13.8	33.7 17.4 15.6 13.8	15.3 16.9 15.3 13.6
10.0	14.9 16.5 14.9 14.9	14.7 16.5 14.9 13.3	32.9 17.0 15.2 13.5	30.7 16.7 15.1 13.4	31.2 16.5 14.9 13.3	31.7 16.7 15.0 13.4	31.7 16.7 15.0 13.4	31.2 16.7 15.0 13.4	14.7 16.2 14.7 13.1
9.6	14.1 15.6 14.1 12.6	13.9 15.6 14.1 12.6	30.0 15.9 14.3 12.8	27.3 15.8 14.3 12.7	27.9 15.6 14.1 12.6	29.4 15.7 14.2 12.7	29.4 15.7 14.2 12.7	27.9 15.7 14.2 12.7	13.9 15.3 13.9 12.5
9.1	13.0 14.3 13.0 11.7	12.8 14.3 13.0 11.5	26.4 14.6 13.2 11.8	22.3 14.4 13.1 11.8	22.8 14.3 13.0 11.7	25.3 14.4 13.1 11.7	25.3 14.4 13.1 11.7	22.8 14.4 13.1 11.7	12.8 14.0 12.8 11.6
8.7	12.3 13.5 12.3 11.1	12.1 13.5 12.3 11.1	24.4 13.8 12.6 11.3	20.8 13.7 12.4 11.2	20.8 13.5 12.3 11.1	23.7 13.6 12.4 11.2	23.7 13.6 12.4 11.2	20.8 13.6 12.4 11.2	12.1 13.2 12.1 11.0
8.2	10.4 11.1 10.4 9.7	10.4 11.1 10.4 9.7	18.6 11.1 10.4 9.7	16.2 11.1 10.4 9.7	15.7 11.1 10.4 9.7	17.8 11.1 10.4 9.7	17.8 11.1 10.4 9.7	15.7 11.1 10.4 9.7	10.4 11.1 10.4 9.7

Notes:
1. *Top of curb elevation in this reach represents beach access
2. Slopes are V:H
3. **Existing Slopes by Reach:

1	2	3	4	5	6	7	8	9
1:20	1:20	Vert.	1:5	1:5	Vert.	Vert.	1:5	1:20

TABLE D-11

Peak Wave Overtopping Data
Nantasket Beach, Hull, MA

Reach No.:	1				2				3			
Length, LF:	400				825				1045			
Wall Height: (Ft., NGVD)	16.9				16.1				16.5			
Slope (Exist-: & 3 proposed)	EX**	1:15	1:20	1:30	EX**	1:15	1:20	1:30	EX**	1:15	1:20	1:30
Stillwater Tide Level (Ft., NGVD)	Rate (CFS)				Rate (CFS)				Rate (CFS)			
10.3	-	100	-	-	-	890	-	-	5300	1500	-	-
10.0	-	-	-	-	-	330	-	-	4800	550	-	-
9.6	-	-	-	-	-	-	-	-	3700	-	-	-
9.1	-	-	-	-	-	-	-	-	1400	-	-	-
8.7	-	-	-	-	-	-	-	-	1000	-	-	-
8.2	-	-	-	-	-	-	-	-	100	-	-	-

Reach No.:	4				5				6			
Length, LF:	1450				50				1385			
Wall Height: (Ft., NGVD)	16.3				15.1*				16.6			
Slope (Exist-: & 3 proposed)	EX**	1:15	1:20	1:30	EX**	1:15	1:20	1:30	EX**	1:15	1:20	1:30
Stillwater Tide Level (Ft., NGVD)	Rate (CFS)				Rate (CFS)				Rate (CFS)			
10.3	7600	1800	-	-	260	120	20	-	5700	2100	-	-
10.0	7000	620	-	-	220	80	-	-	4700	1000	-	-
9.6	5300	-	-	-	180	20	-	-	3600	-	-	-
9.1	1800	-	-	-	110	-	-	-	2100	-	-	-
8.7	1200	-	-	-	80	-	-	-	1400	-	-	-
8.2	-	-	-	-	-	-	-	-	100	-	-	-

Reach No.:	7				8				9			
Length, LF:	780				550				330			
Wall Height: (Ft., NGVD)	17.2				15.8				17.0			
Slope (Exist-: & 3 proposed)	EX**	1:15	1:20	1:30	EX**	1:15	1:20	1:30	EX**	1:15	1:20	1:30
Stillwater Tide Level (Ft., NGVD)	Rate (CFS)				Rate (CFS)				Rate (CFS)			
10.3	3000	100	-	-	3700	1000	-	-	-	-	-	-
10.0	2400	-	-	-	2300	500	-	-	-	-	-	-
9.6	1800	-	-	-	1800	-	-	-	-	-	-	-
9.1	1000	-	-	-	1000	-	-	-	-	-	-	-
8.7	400	-	-	-	700	-	-	-	-	-	-	-
8.2	-	-	-	-	-	-	-	-	-	-	-	-

Notes:
1. All non-reported overtopping values were negligible
2. *Top of curb elevation in this reach represents beach access
3. Slopes are V:H
4. **Existing Slopes by Reach:

1	2	3	4	5	6	7	8	9
1:20	1:20	Vert.	1:5	1:5	Vert.	Vert.	1:5	1:20

result in a significant hydraulic gradient enabling floodwaters to be discharged into the interior Hingham Bay.

The study area is surrounded by hills in the northwestern and southern sections. To the north, the study limit is located at Phipps street, and to the south, the limit is located at Atherton Road (at the end of the sea wall). A large portion of the study area consists of impervious sections that have been developed to provide parking areas for beach visitors and businesses, leaving only small random pervious sections for infiltration.

b. Drainage System. Local small drains are located in the parking lot adjacent to the seawall draining rainfall runoff from the streets and parking lot toward the beach. Although no detailed storm sewer maps are available, it appears that drainage along Hull Shore Drive and Nantasket Avenue is conveyed by pipes or overland flow to the interior Hingham Bay.

c. Recent Flood Events. The most recent storms experienced in the area were the Halloween storm of 31 October 1991 and the lesser storm of 12 December 1992. The October 1991 storm event caused considerable damage along the eastern coast of the United States. Recorded tide levels at Boston were about 1 foot less than peak levels associated with the "Blizzard of 1978." Peak wind gusts recorded ranged from 78 mph at the National Weather Service Office in Chatham to 68 mph at Marblehead, and 55 mph at Boston. Heavy rain accompanied this storm over a 3-day period starting late on the 30th with 4 to 6 inch totals in the area south of Boston. Boston Logan Airport recorded 2.71 inches. Comparative data for recent events, along with recorded ocean levels and windspeeds and directions in the Nantasket Beach area, are presented in table D-12.

d. Hydrologic Zones. Because of the very flat topography of the area, any shallow surface ponding extends over a wide area. Major streets in the area, Nantasket Avenue and Hull Shore Drive, run perpendicular to the natural flow path in a north-south direction serving as blockage of the flow. Smaller streets running parallel to the flow path convey flow to the bay side area.

To gain a better understanding of flow through this area, Water Control Division personnel made a site visit during the December 1992 storm. Wave overtopping and minor rainfall excess were observed to determine the most likely direction

TABLE D-12

RECENT FLOODS AT NANTASKET BEACH
COMPARATIVE HYDROLOGIC DATA

FLOOD EVENT	7 Feb 1978	19 Feb 1972	12 Nov 1968	25 Jan 1979	30 Oct 1991	12 Dec 1992
Ocean Tide (ft-NGVD) Observed *	10.4	9.2	7.8	9.3	9.4	9.4
Tide Freq., Est. (%)	0.9	10	100	8	7	7
Max. 1 Hr rainfall (in.)	0.2	0.5	0.3	0.3	0.3	0.5
Storm Rainfall (in.)	2.8/48 hr	2.5/24 hr	1.8/24 hr	2.1/24 hr	2.5/48 hr	4.2/24
Max. Wind (Fastest-mile, MPH)	44	47	54	45	37	51
Wind Direction	NE	NE	NE	E	NE	NE

* Observed values are as corrected by NOS, 1992

of floodflows. Following Nantasket Avenue from north to south, minor ponding areas were located mostly inside the beach parking lots adjacent to the seawall. It was determined that the largest percentage of flooding in the parking lots and streets resulted from wave overtopping, while the rainfall runoff contribution was minimal.

Based on observation during this event, as well as from analysis from FEMA flood plain mapping and results of recent Corps surveys, the area was subdivided into three hydrologic zones as shown in plate D-2. These zones were determined by street elevations and depressions temporarily confining floodwaters. It is believed that each zone acts independently to convey flood waters. Overtopping floodwaters for each zone subsequently reach elevations high enough to convey discharge into the bay area. A short description of each area follows:

In the northernmost section between Phipps Street and Whitehead Street, it was observed that street elevations direct flow toward the north of the peninsula and away from the study limits. Further hydraulic analysis of this section shows no overtopping in this section of the project. Having only minimal runoff from rainfall and no overtopping, this small section was excluded from further study.

Zone 1 with an area of 19 acres, was determined to be located between Whitehead Street and the north end of Bay Street. Minor ponding was observed in this zone at the intersection of Bay Street and Hull Shore Drive, which runs parallel to the seawall and Nantasket Ave. Analysis of mapping and surveys indicates that as depth increases, flow begins to be conveyed through Bay Street.

Zone 2, with a 25-acre area, was located between the north end of Bay Street and Wharf Avenue. The major sections of ponding in this zone are the beach parking lot and the MDC parking area between Nantasket Avenue and George Washington Boulevard. Analysis of mapping and surveys indicates that as depth increases, water will begin to flow through the south end of Bay Street and the area behind the MDC parking lot.

Zone 3, with an area of 33 acres, was located between Wharf Avenue and the south end of the sea wall at Atherton Road. Overtopping water would first pond adjacent to the seawall, then flow into a storage area behind the Horizon Condominiums between Park Avenue, Nantasket Avenue, and George Washington Boulevard. This 9.2-acre area fills very quickly and flows would be conveyed over George Washington Boulevard into Hingham Bay.

e. Interior Storage Capacity. Interior storage capacity curves for the flood zones were developed to determine if there were any significant volume in the area. Curves were estimated from FEMA flood plain maps and profiles developed from recent Corps surveys. From storage capacity analysis, it was determined that the three zones had minimal storage capacity and that during flood conditions, streets and low areas will generally pass overtopping waters quickly toward the bay.

f. Rating Curves. Stage discharge relationships for each zone were computed to estimate depth of floodwaters from overtopping discharges. Each hydrologic zone has at least two outlet sections where floodwaters would be conveyed into the bay side of the peninsula. Rating curves at each outlet were developed from cross sections taken from FEMA flood plain maps and October 1992 Corps surveys, as well as information gathered during site visits. Manning's "n" values ranged from 0.08 for less effective flow areas to 0.035 for flow along the streets.

g. Existing Conditions Flood Frequencies. Stage discharge rating curves were used to determine existing condition flood stage-frequency curves for each hydrologic zone as shown on plate D-3. Overtopping discharge information used to develop these rating curves was obtained using overtopping discharge rates as shown on table D-11. Information for the October 1991 storm obtained from merchants and residents of the area, was compared to developed curves to determine reasonableness of the curves. Residents reported elevations up to top of curve levels or about 0.5 foot stage during the October 1991 flood. Other locations reported elevations ranging from 2 inches to 1 foot. The October 1991 stillwater level was about a 10-year event; therefore, the developed interior curves appear reasonable. The only area where depths were reported to be more significant was behind Horizon Condominiums. Reported depths were 2 to 3 feet in this localized ponding area, located approximately 2.5 feet below street level.

h. Modified Elevation Frequencies. The same stage discharge rating curves were used to develop modified elevation frequency curves for hydrologic flood zones as shown on plate 3. Discharge information to develop the modified elevation frequency curves was taken from table D-11. Using a design fill beach slope of 1:15, would result in reduction of average depths of 0.4, 0.7, and 1 foot on zones 1, 2, and 3, respectively. Other beach fills analyzed showed no overtopping other than a small amount at reach 5 for the 100-year stillwater event.

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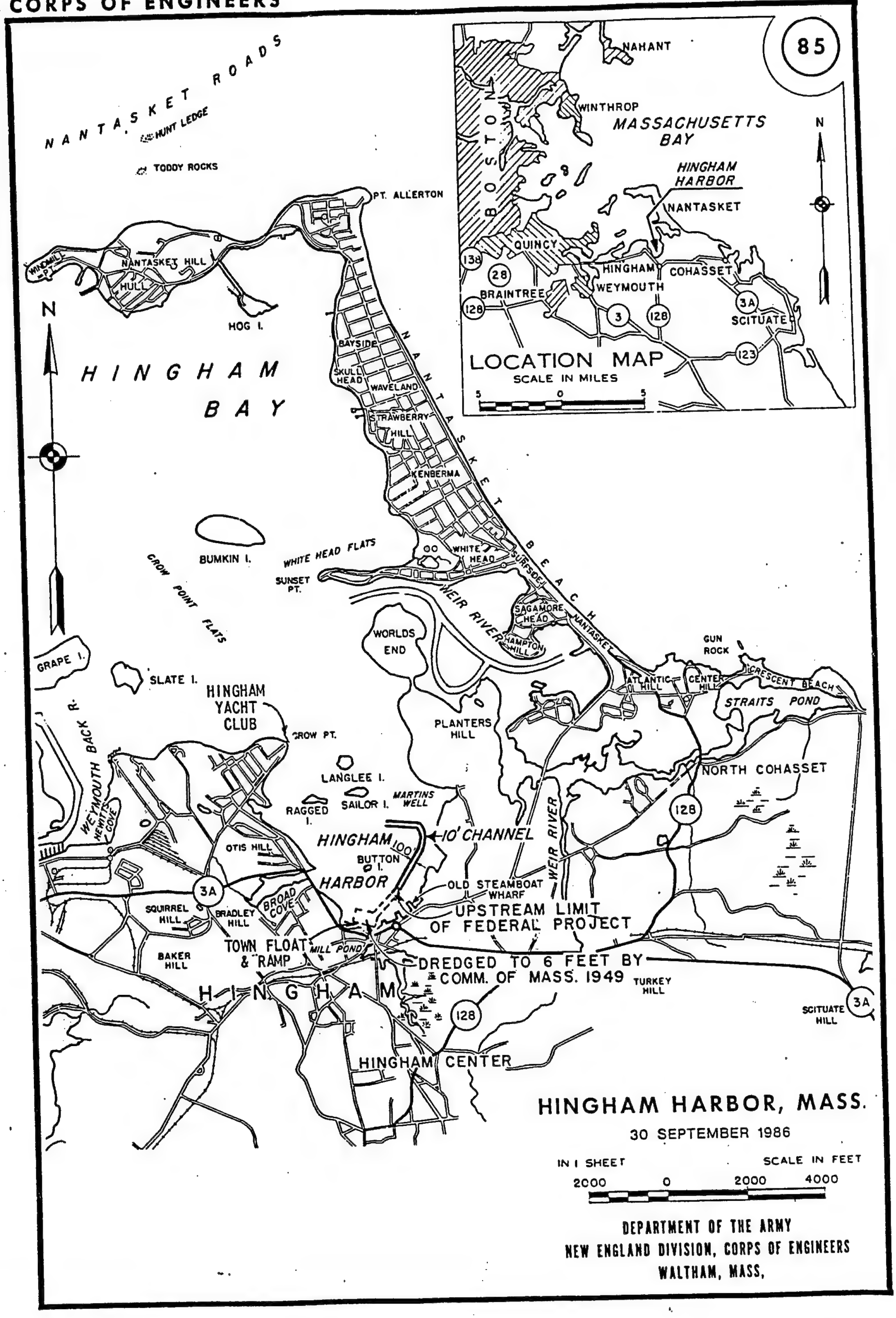
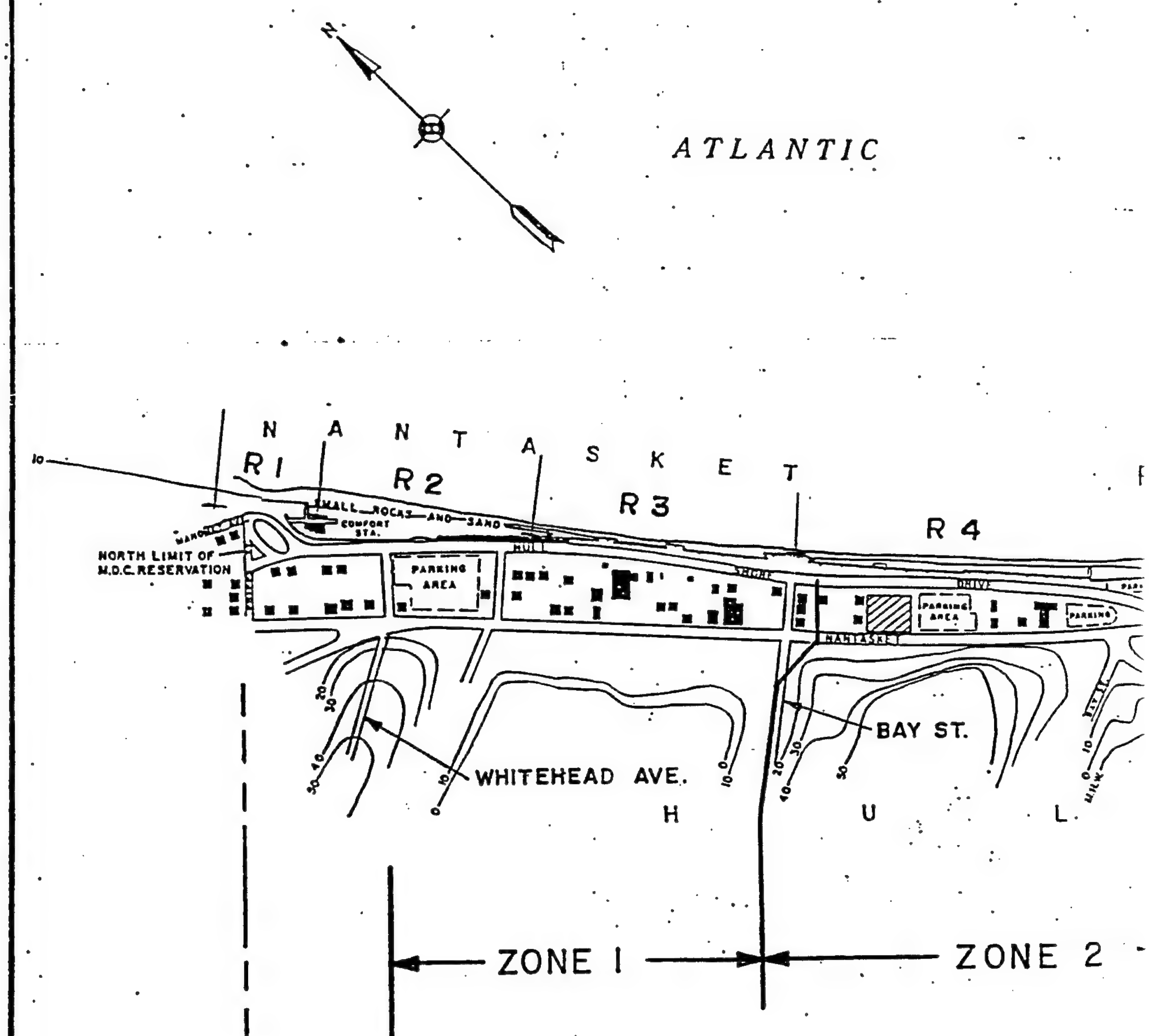


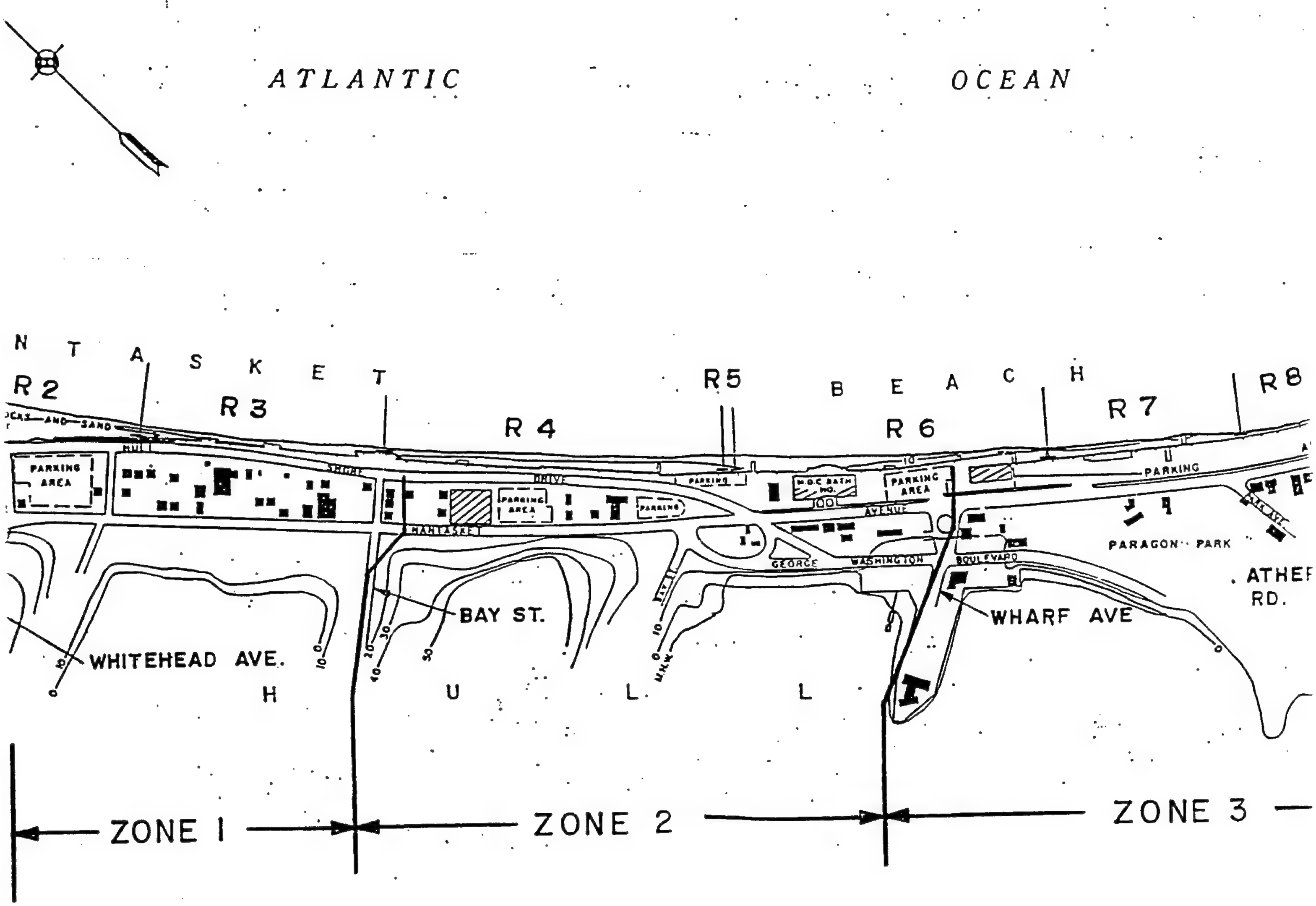
PLATE D-1



Notes:

1. Beach front reaches 1 -
runup and overtopping ar

2. Interior zones 1 - 3 wer
frequency curves.

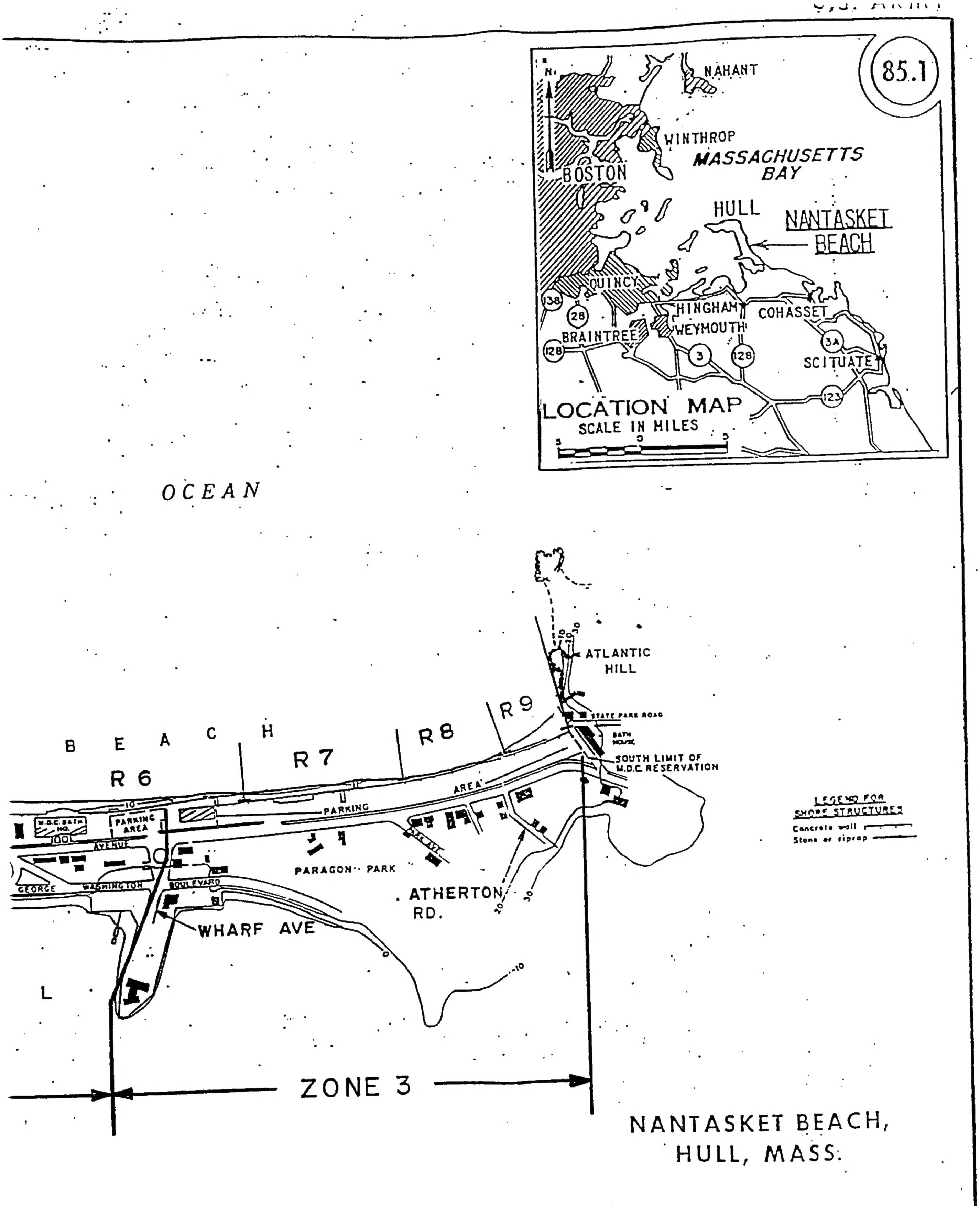


Notes:

1. Beach front reaches 1 - 9 (shown as R1, etc) were used for runup and overtopping analyses.

2. Interior zones 1 - 3 were used to develop interior stage frequency curves.

2



NANTASKET BEACH,
HULL, MASS.

(shown as R1, etc) were used for
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used to develop interior stage

SCALE IN FEET

200 0 200 400 600

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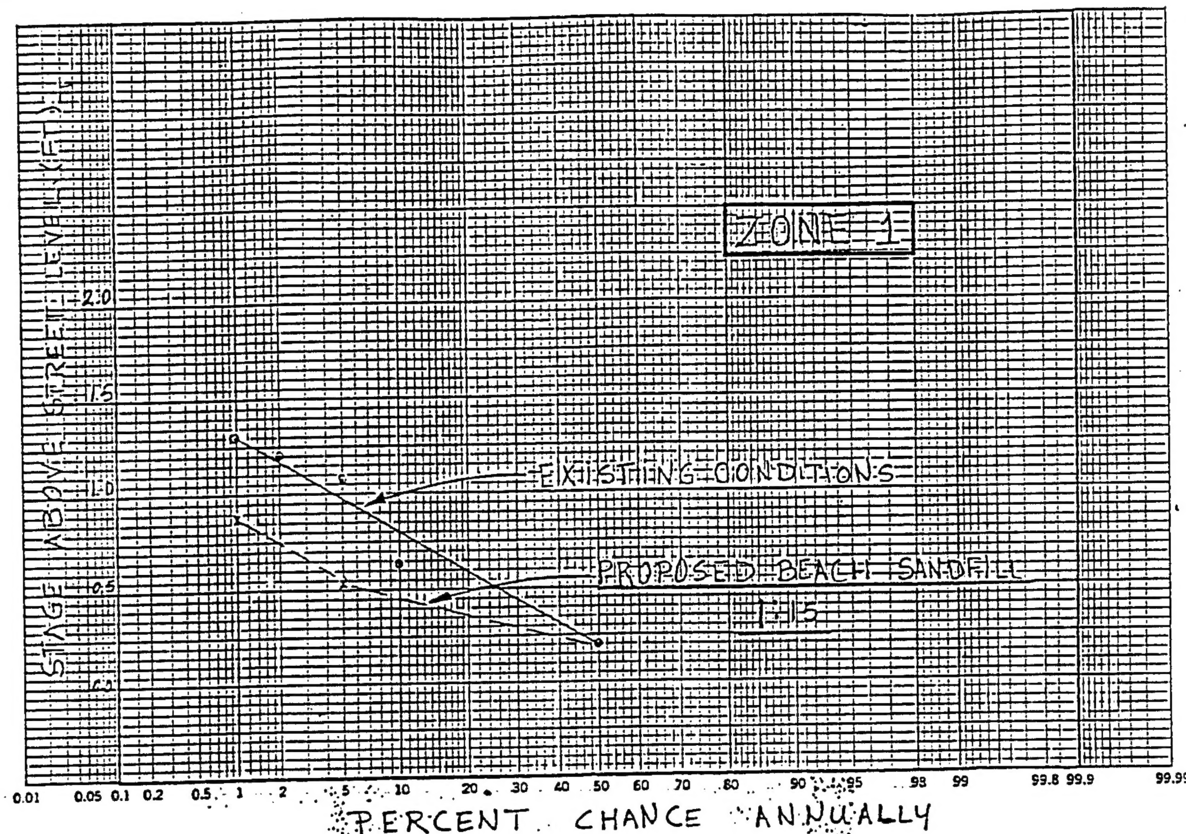
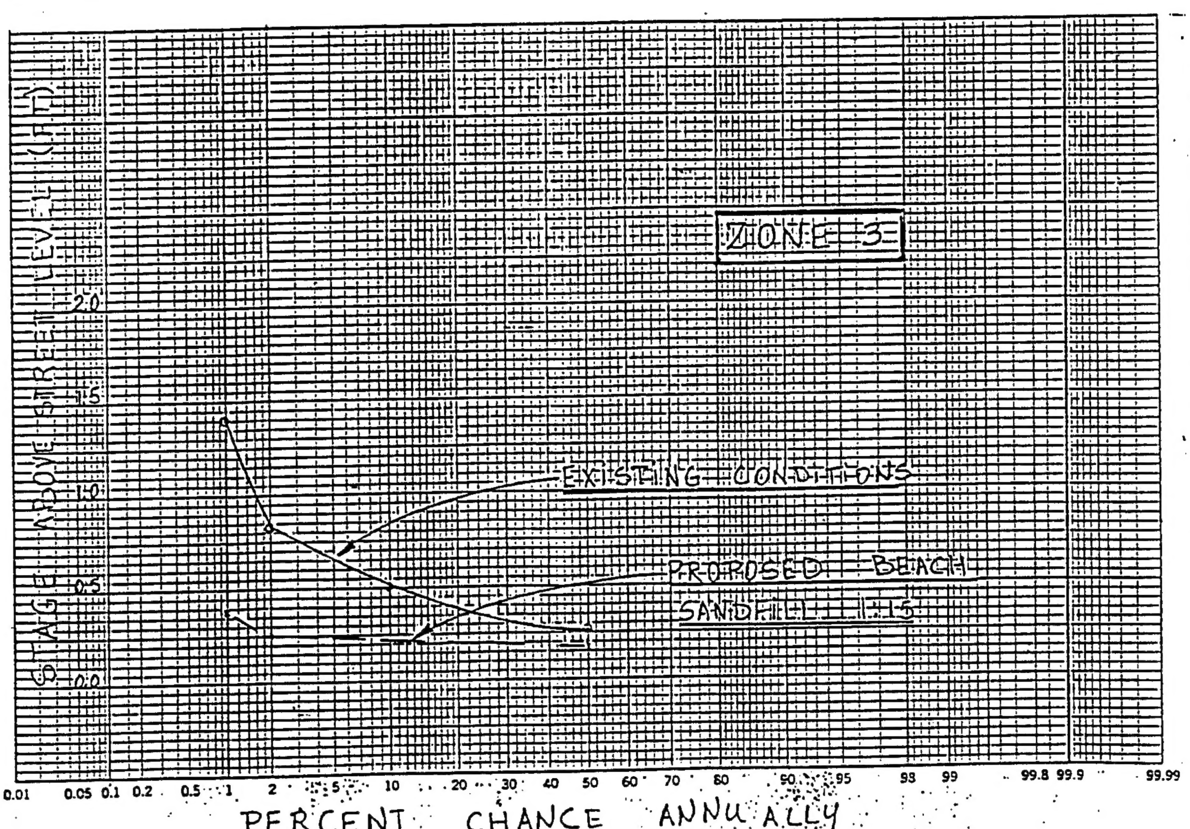
WALTHAM, MASS.


STAGE ABOVE STREET LEVEL (FT)
ZONE 1
EXISTING CONDITIONS
PROPOSED BEACH SANDFILL 1:15
PERCENT CHANCE ANNUALLY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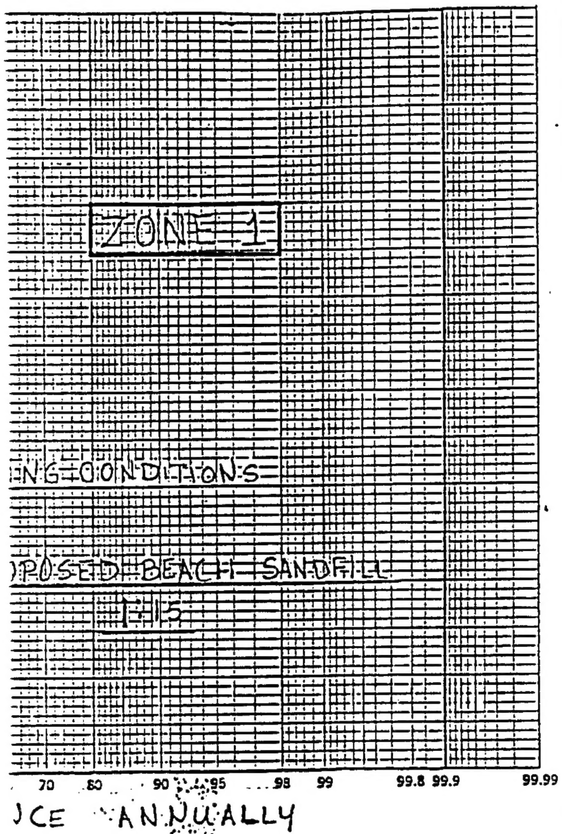
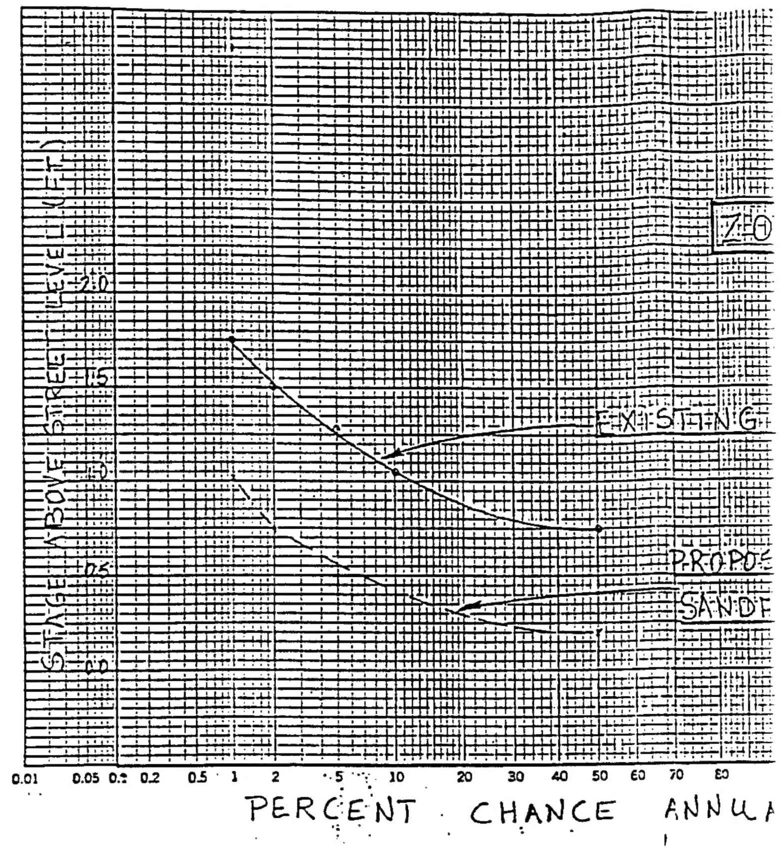
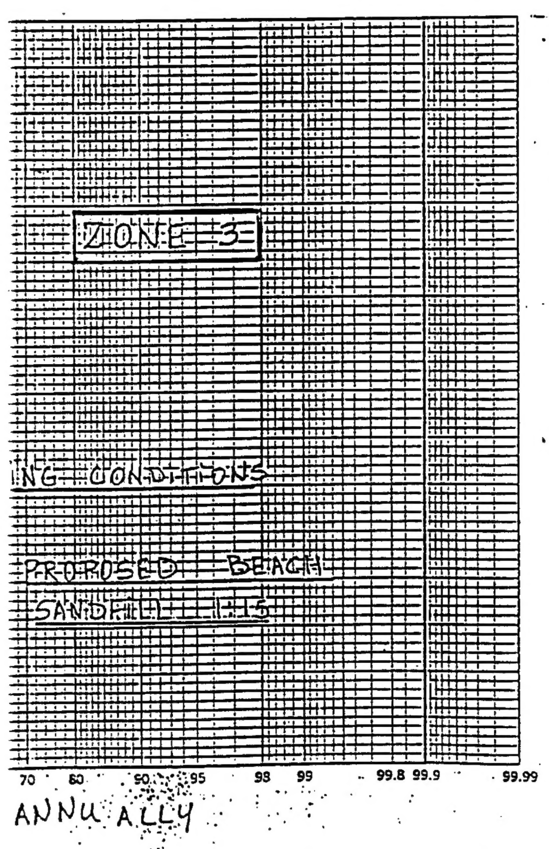
ZONE 3
EXISTING CONDITIONS
PROPOSED BEACH SANDFILL 1:15
PERCENT CHANCE ANNUALLY

0







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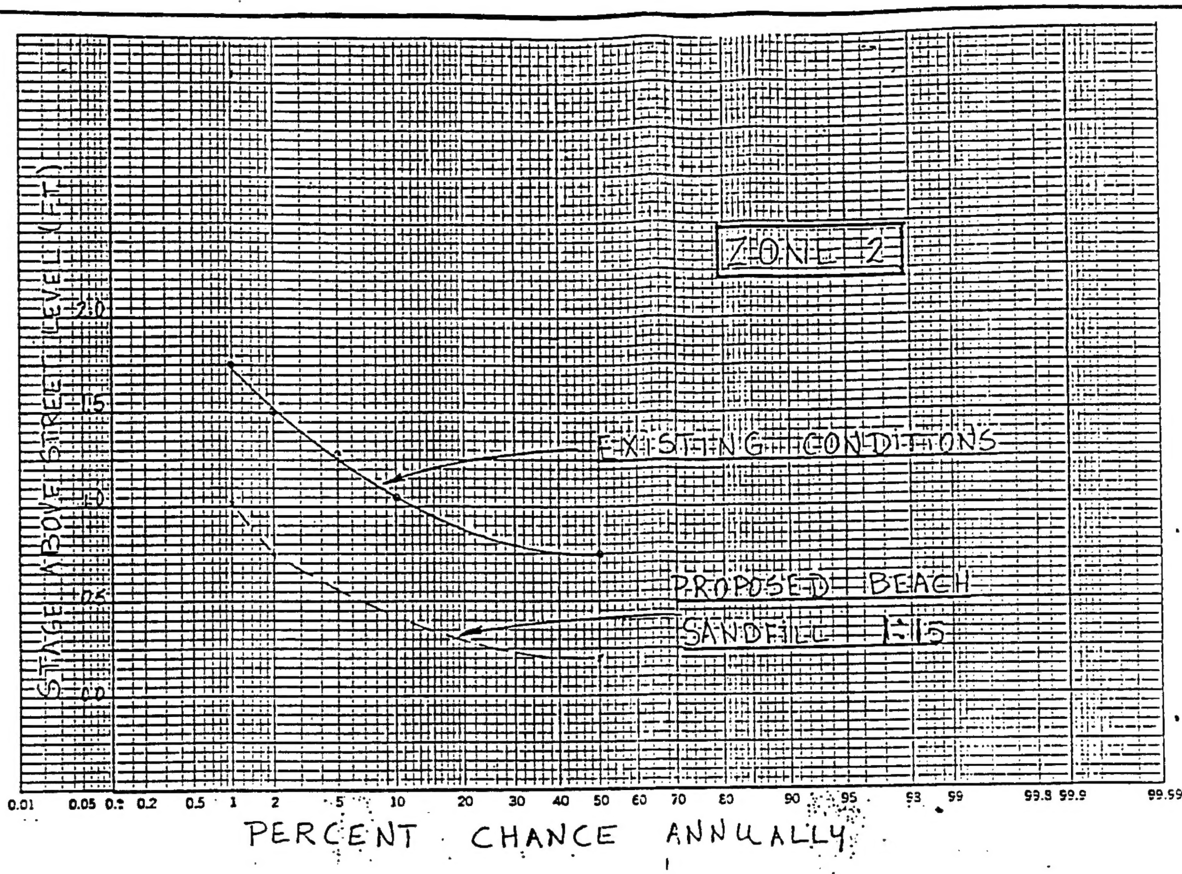

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NANTASKET BEACH – HULL, MA
INTERIOR ZONES
STAGE FREQUENCY CURVES

HEB 4/93

3